Manitoba
Natural Resources

THE RAFFERTY/ALAMEDA DAMS PROJECT

IMPLICATIONS FOR MANITOBA

October, 1988

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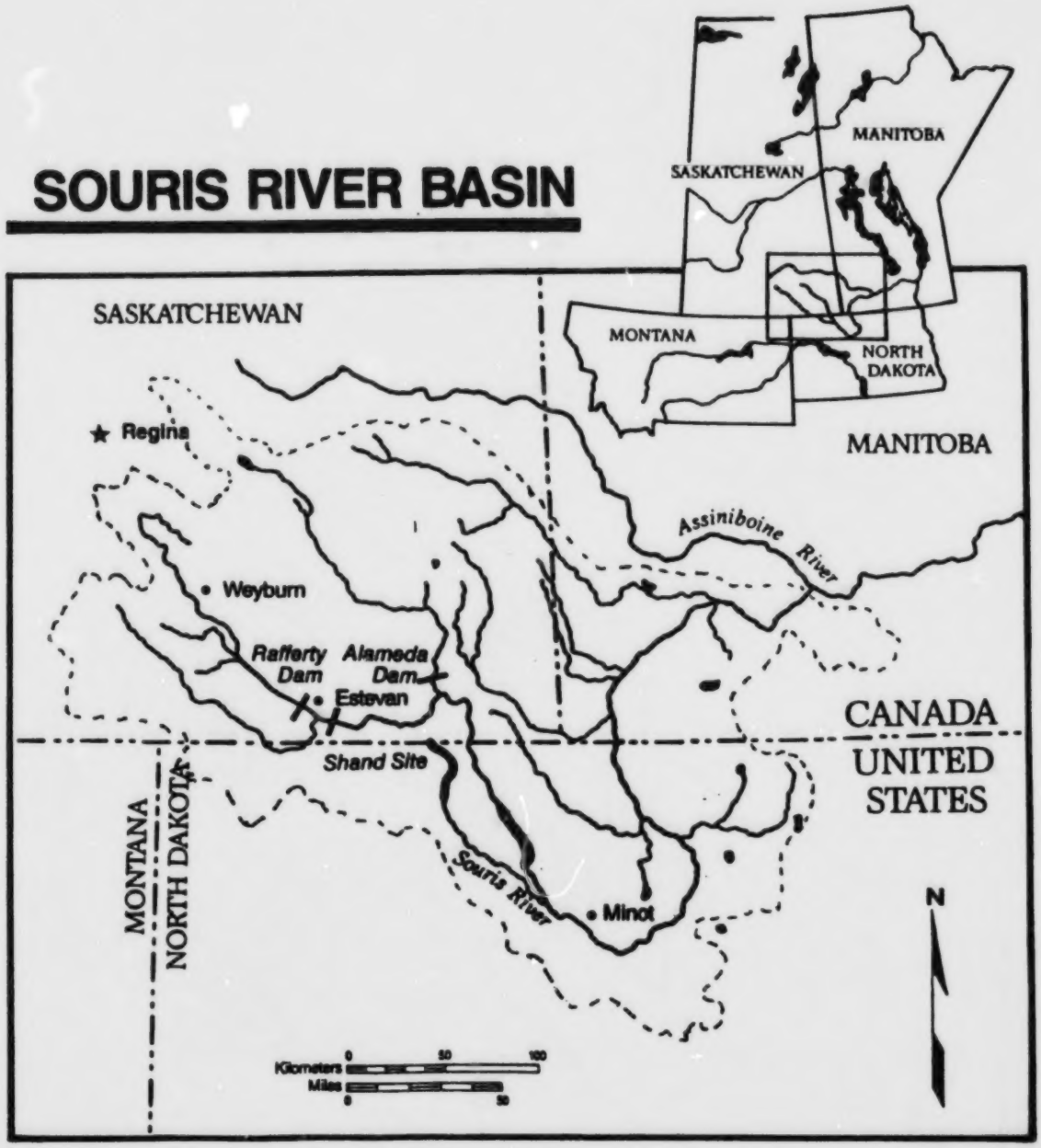
PREFACE

This report was produced by an Interdepartmental Committee composed of staff from the Manitoba Departments of Environment and Workplace Safety and Health, Natural Resources and Executive Council. This Committee has consulted technical staff of Environment Canada, the Province of Saskatchewan, the State of North Dakota and United States federal agencies during the course of its work. The Committee's terms of reference were to:

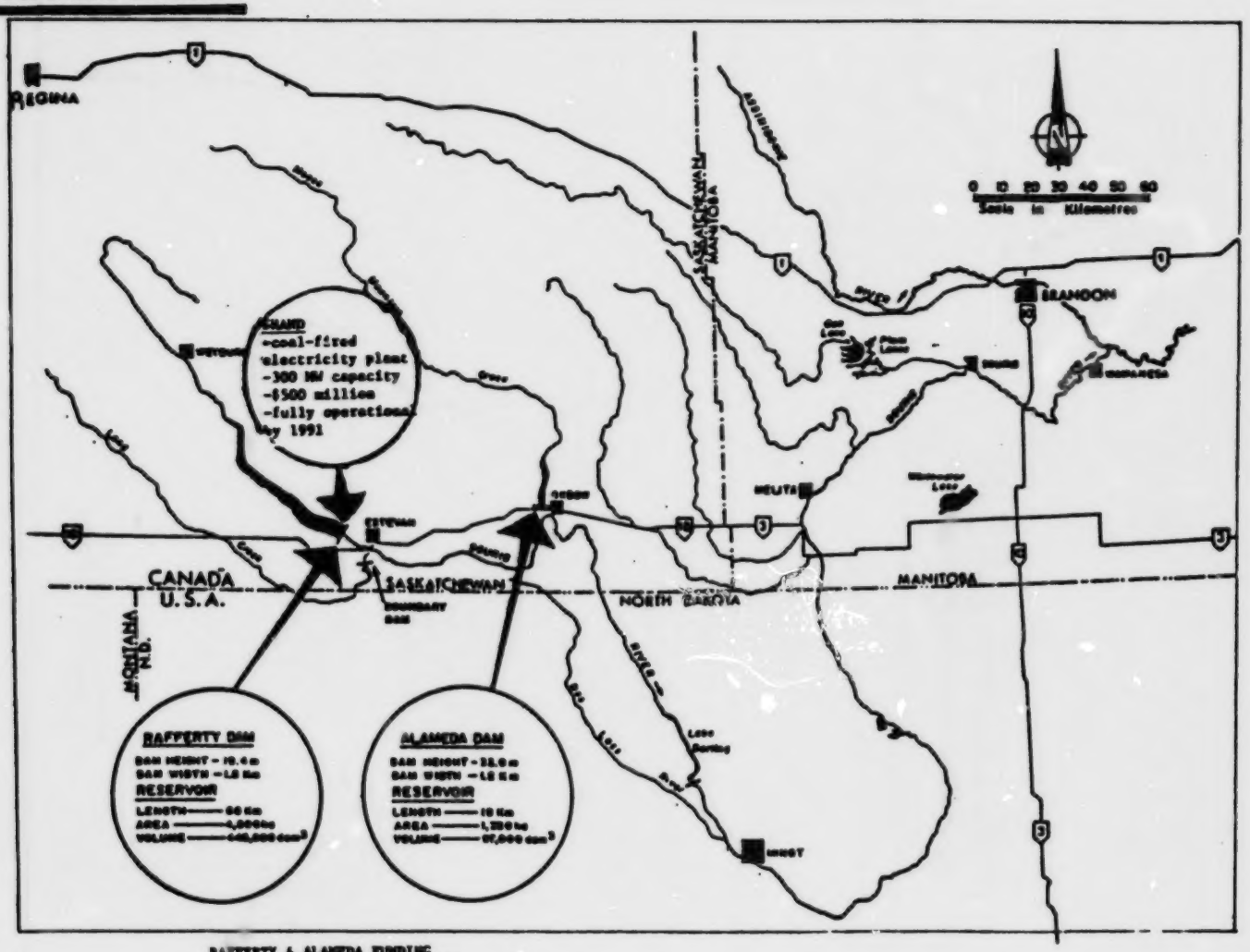
- assemble the relevant data and assessment documentation related to water flow and water quality on the Souris River that has been generated as a result of the process required for the approval of the Souris River Basin Project (Rafferty/Alameda dams);
- review the assembled data and assessment documentation and identify, if possible, any water flow or water quality impacts which may occur in Manitoba as a result of the project;
- identify any gaps or deficiencies in the data and assessment documentation as it relates to Manitoba; and
- develop recommendations for future action by Manitoba.

MAPS

SOURIS RIVER BASIN

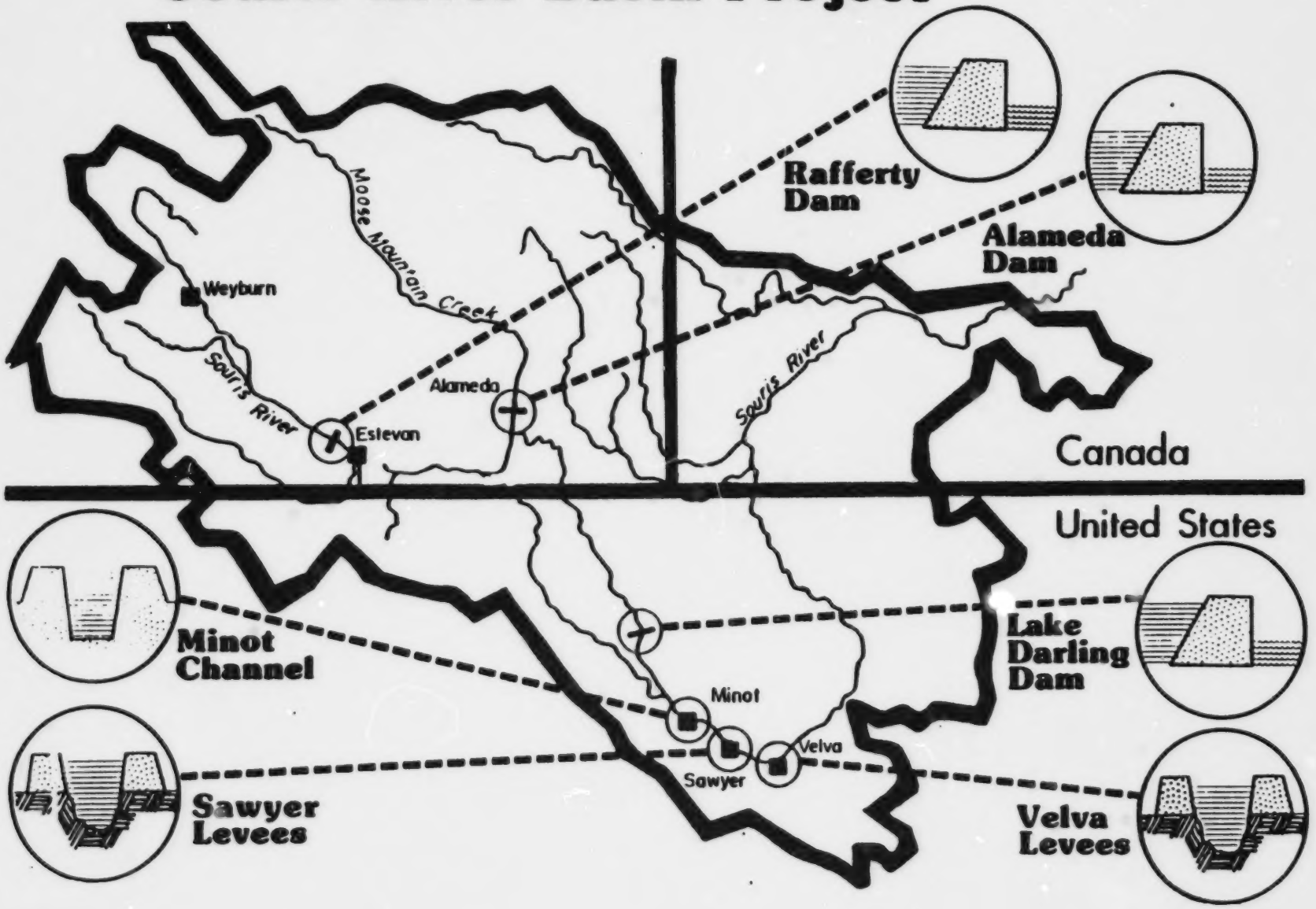


SOURIS RIVER BASIN



RAFFERTY & ALAMEDA FUNDING
Saskatchewan -$120 Million Cdn.
U.S. Govt. -$41.1 Million US

Souris River Basin Project



I

INTRODUCTION

The Souris River, with headwaters in southeastern Saskatchewan, flows south into northwestern North Dakota, then turns north through southwestern Manitoba joining the Assiniboine River at Wawanesa. The Government of Saskatchewan and the United States Army Corps of Engineers have proposed and agreed upon a project for the Souris River Basin to provide for water supply in Saskatchewan and flood control in North Dakota. Manitoba is not directly involved in the construction or financing of the project but as a downstream recipient is an interested party.

Manitoba's interests are generally protected through the existing Canada-United States Boundary Waters Treaty of 1909 and certain water flows are specifically guaranteed under the 1959 Interim Measures administered by the Souris River Board of Control, a body responsible to the International Joint Commission. Because of the international nature of the project, a Canada-United States agreement is required and this provides an opportunity to further safeguard Manitoba's interests.

BACKGROUND

In February 1986, the Premier of Saskatchewan announced that Saskatchewan would construct the Rafferty Dam on the Souris River and the Alameda Dam on Moose Mountain Creek. The United States, through the U.S. Army Corps of Engineers, would cooperate and consult with Saskatchewan on the project. The United States committed funding for the project to increase water storage capacity and provide flood control benefits to North Dakota, particularly the City of Minot. The $41.1 million (U.S. dollars) contribution is to be split between the Rafferty ($26.7 million) and the Alameda ($14.4 million) dams. The City of Minot will contribute about $5.0 million towards the total cost of the project.

The project will provide flood control on both sides of the border and flood protection for the City of Minot. The Rafferty Dam (expected to be completed by 1990) will provide water storage with its primary purpose being to supply water for the cooling of the Shand generating station. Additional benefits expected by Saskatchewan from the project are irrigation, crop diversification and new recreational opportunities. Saskatchewan also announced that the Saskatchewan Power Corporation would construct a coal-fired thermal electric generating plant at Shand near Estevan. The $500 million plant would generate 300 megawatts of electricity and is expected to be fully-operational in 1991.

The Souris Basin Development Authority (SBDA) was established by the Saskatchewan Government to oversee construction of the dams; complete funding arrangements (including U.S. participation); hold consultations with the public, and ensure that all environmental and regulatory requirements are met.

The U.S. Army Corps of Engineers is the lead agency for the United States. Other agencies involved are: U.S. Fish and Wildlife Service; North Dakota State Water Commission; North Dakota State Health Department; and the U.S. Environmental Protection Agency.

Manitoba's initial involvement with the Souris River Basin Project was through the Department of Natural Resources, Water Resources Branch and primarily related to water quantity and water flow aspects. The Water Resources Branch has utilized data provided by the project proponents and developed flow simulations under varying regimes to determine the affect of the project operations on reaches of the Souris River downstream of Lake Darling. These simulations, generally completed by the end of 1987, are dealt with in greater detail in Section III and Appendix 7.

In November of 1987 the Manitoba Department of Environment and Workplace Safety and Health assumed an active role in multilateral activities related to the project. With much of the flow data compiled, the emphasis could be shifted to water quality issues and the relationship between water flows and water quality. (Refer to Section IV.)

In the late fall of 1987 the Government of Canada, Department of External Affairs, invited Manitoba and Saskatchewan to Ottawa to review activities related to the Souris Basin Project and to discuss means of coordinating activities in Canada and relations with the United States Government. Staff from the Intergovernmental Relations Secretariat and Natural Resources, Water Resources Branch attended the meeting and presented Manitoba's views on the project.

In the spring of 1988 Canada extended an invitation to Manitoba to be represented on the Canadian Delegation formed to negotiate an agreement with the United States on the Souris River Basin Project. The Canadian Delegation is led by the Department of External Affairs and includes representatives from Environment Canada, Saskatchewan and Manitoba. Manitoba representatives include staff from the Department of the Attorney-General, the Department of Environment and Workplace Safety and Health, the Department of Natural Resources, and Executive Council (Intergovernmental Relations Secretariat). It met for the first time May 20, 1988. Negotiations with the United States have been initiated and are continuing at this time.

CHRONOLOGY OF EVENTS

The following chronology of events (to October 1988) presents a detailed list of activities relating to the Souris River Basin Project. It cites multilateral, interjurisdictional meetings but not bilateral and interdepartmental meetings of officials.

February 12, 1986 - Saskatchewan Government announced that it will construct a $500 million thermal electric generating station at Shand, 10 kilometres from Estevan. The 300 Megawatt station is to be fully-operational in 1991.

- Conditional agreement with the United States to build the Rafferty and Alameda Dams on the Souris River at a total cost of $120 million was also announced. The U.S. Governmnent has been asked to contribute $41.1 million (U.S.)

March 6, 1986 - The Souris Basin Development Authority (SBDA), a Crown Corporation, was established (by Order-in-Council) to oversee the Rafferty/Alameda project.

April 22, 1986 - Meeting in Winnipeg with representatives from Manitoba (Natural Resources, Water Resources Branch), Saskatchewan, North Dakota (State Water Commission) and the U.S. Army Corps of Engineers to discuss a process to study possible impacts of the project on North Dakota and Manitoba.

May 7-8, 1986 - Meeting in St. Paul, Minnesota with representatives from the U.S. Army Corps of Engineers, Saskatchewan (SBDA, Sask Power) North Dakota (Water Commission, City of Minot), Manitoba (Natural Resources, Water Resources Branch) relating to an operating plan and, primarily, an evaporation agreement for the reservoirs in Saskatchewan.

June 12, 1986 - Cochrane-Lavalin Inc. was selected by Saskatchewan as the engineering consultants to carry out detailed design and specification works for Rafferty and Alameda.

August 18, 1986 - SBDA put a hold on consideration of the Environmental Impact Statement on the Rafferty and Alameda Dams pending completion of negotiations with the United States on water-related issues (evaporation sharing, reservoir filling and operations, etc.).

August 21, 1986 - Saskatchewan Environment announced a Board of Inquiry to examine the environmental implications of the planned projects.

August 27, 1986 - Meeting in Minot, North Dakota with representatives from the U.S. Army Corps of Engineers, Saskatchewan (SBDA, Sask Water) North Dakota (Water Commission, City of Minot), Manitoba (Natural Resources, Water Resources Branch) relating to an operating plan and, primarily, an evaporation agreement for the reservoirs in Saskatchewan.

September 2, 1986 - Shand Engineering Contract awarded to Saskmont Engineering Ltd. and Agro Industries Limited.

September 12, 1986 - Marubeni-Hitachi of Japan awarded the $72 million contract to manufacture and install two complete turbines at Shand. The company will establish a plant in Saskatoon to manufacture turbines.

September 18, 1986 - SBDA announced a tentative agreement with the United States on evaporation sharing for the Rafferty and Alameda reservoirs.

October 1986 - United States House and Senate conferees reached agreement on a conference report on the Omnibus Water Resources Authorization and Policy Bill. The report authorizes the U.S. Army Corps of Engineers to cooperate with Canadian governments to study and construct reservoir projects for water storage in the Souris River basin in Canada and flood control benefits in the U.S.A. and finance up to $26.7 million if only the Rafferty dam is constructed and a maximum of $41.1 million if both Rafferty and Alameda dams are constructed.

November 17, 1986 - U.S. Army Corps of Engineers received general authorization for the Souris River Basin Project under Section 1124 of the 1986 Water Resources Development Act, Public Law 99-662.

June 2, 1987 - Souris Basin Development Authority submitted its Environmental Impact Statement to Saskatchewan Environment for review. Public review period Aug. 17 - Sept. 16.

- SBDA announced agreement in principle between Saskatchewan and U.S. interests on an operating plan for the Souris River. (U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, North Dakota State Water Commission, Souris River Joint Water Resources Board, City of Minot).

August 26, 1987 - Saskatchewan extended the public review period on the Rafferty and Alameda Environmental Impact Statement to October 16 (an additional 30 days).

September 9-21, 1987 - Rafferty/Alameda Board of Inquiry held public hearings in Saskatchewan.

October 6, 1987 - Public review period for documents on the proposed thermal generating station at Shand scheduled for Oct. 8 - Nov. 6. The Environmental Impact Statement and the Saskatchewan Environment and Public Safety's technical review were released.

November 18-20, 1987 - A Water Quality workshop on the Souris Reservoir Development Project was held in Regina. Represented were SBDA; Saskatchewan Environment, Sask Water, Environment Canada, North Dakota State Water Commission, N.D. Department of Health, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service.

November 19, 1987 - The Draft U.S. Army Corps of Engineers Environmental Impact Statement (EIS) on the Souris River Basin Project was filed with the U.S. Environmental Protection Agency for entry in the Public Registry.

November 20, 1987 - Canada-United States meeting in Washington on the Souris River/Rafferty and Alameda Dams project. Canada (External Affairs; Environment Canada) Saskatchewan (Sask Power; Souris Basin Development Authority) met with U.S. representatives from the Environment and Public Works Committee; Corps of Engineers; Fish and Wildlife Service; Environmental Protection Agency; the Department of State and the North Dakota State Water Commission. The meeting was held at Saskatchewan's request.

November 27, 1987 - The U.S. Army Corps of Engineers Draft EIS was entered in the Public Registry. Following a 45 day period for public comment, the Corps of Engineers had 60 days to address questions raised. Preparation of the Final EIS followed this process.

November 27, 1987 - Canada (Dept. of External Affairs; Environment Canada), Saskatchewan (SBDA, Sask Water, Sask Power) and Manitoba (Intergovernmental Relations; Natural Resources, Water Resources Branch) meeting on the Souris River Rafferty and Alameda Dams project in Ottawa.

December 1, 1987 - Meeting of Officials in Winnipeg on water quantity and water quality. Manitoba (Natural Resources, Water Resources Branch; Environment; Intergovernmental Relations), Saskatchewan (SBDA; Sask Water;) Environment Canada; North Dakota (State Water Commission) and the U.S. Army Corps of Engineers (St. Paul) in attendance.

December 21-22, 1987 - A Souris River Water Quality Information meeting was held in Regina with representatives from the Manitoba Department of Environment, Environment Canada, Souris Basin Development Authority, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Services, and North Dakota (Health; Water Commission).

January 7, 1988 - Saskatchewan applied to Environment Canada for a license under the International Rivers Improvement Act to construct Rafferty and Alameda dams.

January 25, 1988 - The Government of the United States of America officially forwarded a proposed draft agreement on the Souris River Basin Project to the Government of Canada for the consideration by Canadian representatives. The draft Agreement was forwarded to Manitoba and Saskatchewan.

January 27, 1988 - Saskatchewan's Rafferty-Alameda Board of Inquiry delivered its Final Report to the Minister of Environment and Public Safety.

February 15, 1988 - The Saskatchewan Department of Environment and Public Safety gave Ministerial Approval under the Environmental Assessment Act for the construction of and operation of the Rafferty Dam on the Souris River and the Alameda Dam on Moose Mountain Creek.

February 16, 1988 - The Saskatchewan Department of Environment and Public Safety gave Ministerial Approval under the Environmental Assessment Act for the construction and operation of the Shand Generating Station.

March 23, 1988 - Preliminary work on the construction of coffer dams on the Souris River for the Rafferty Dam project commenced.

May 15, 1988 - Saskatchewan held an "official construction kick-off" ceremony for the Shand Generating Station.

May 20, 1988 - The first meeting of the Canadian Delegation established to negotiate the international agreement with the United States on the Souris River Basin Project was held in Ottawa.

May 25, 1988 - Saskatchewan awarded a contract to Babcock and Wilcox Canada to build, erect, and commission two steam generators for the Shand Power Station. Delivery of the first unit is scheduled for 1989 to be in service by July 1992.

May 31, 1988 - The second official meeting of the Canadian Delegation was held in Ottawa.

June 3, 1988 - Manitoba (Environment; Natural Resources; Intergovernmental Relations), Saskatchewan (SBDA; Sask Water; Sask Power) and Environment Canada met in Winnipeg.

June 8, 1988 - The Government of Canada officially forwarded to the Government of the United States of America a Canadian counter-draft (Discussion Draft) of a proposed Canada-U.S.A. agreement relating to the Souris River Basin Project.

June 17, 1988 - Environment Canada granted a license under the International River Improvements Act to Saskatchewan to construct, operate and maintain the Rafferty Dam on the Souris River and the Alameda Dam on Moose Mountain Creek.

June 22-23, 1988 - The first meeting of the Canadian and American delegations on the proposed Canada-United States of America agreement respecting the Souris River Basin Project was held in Ottawa. The Canadian Delegation was made up of representatives from the Department of External Affairs, Environment Canada, Manitoba and Saskatchewan. The U.S. Delegation was made up of representatives from the U.S. Department of the Army and the State Department (U.S. Embassy).

July 22, 1988 - U.S. Army Corps of Engineers released its "General Plan Report and Final Environmental Impact Statement" on the Souris River Basin Project.

August 5, 1988 - The U.S. forwarded to Canada a revised proposed draft agreement on the Souris River Basin Project.

September 9, 1988 - The third Canadian Delegation meeting was held in Ottawa.

September 20, 1988 - U.S.A. EPA issued comments on the U.S. Army Corps of Engineers Final Environmental Impact Statement.

September 22, 1988 - The fourth Canadian Delegation meeting was held in Ottawa.

October 3, 1988 - The Government of Canada officially forwarded to the Government of the United States of America a further counter-draft for a proposed Canada-U.S.A. agreement relating to the Souris River Basin Project.

II

PROJECT LICENSING AND APPROVAL

In Saskatchewan the proposed Rafferty and Alameda Dams require licenses from the Department of Environment and Public Safety as set out in the Environmental Assessment Act. In addition, as the project alters an international waterway, a federal license is required under the International River Improvements Act (IRIA) administered by Environment Canada. Given that the Canadian project occurs entirely within the boundaries of the Province of Saskatchewan, Manitoba has no direct jurisdiction over any aspect of the project.

In the United States, as the federal government is providing funds for the project, there must be compliance with the provisions of National Environmental Policy Act (NEPA) including an Environmental Impact Statement.

The proposed evaporation sharing provision allowing Saskatchewan to retain 60% of the water under certain conditions, requires a revision to the International Joint Commission 1959 Interim Measures (Docket #41) (Appendix 6).

All parties must abide by the obligations set out in the Boundary Waters Treaty of 1909 (Appendix 5). Furthermore, the nature of the project requires an international agreement to facilitate development and water management in the Souris River Basin.

THE SASKATCHEWAN ENVIRONMENTAL ASSESSMENT ACT (1980)

The Saskatchewan Environmental Assessment Act stipulates that an Impact Assessment must be conducted if a development project will have a major impact on a specific geographic area; it will limit or preempt the use of provincial resources; or if it is or may be of major public concern. The proposed Rafferty and Alameda dams necessitated an Environmental Impact Assessment. The following major steps in the process have occured:

- the proponent, the Souris Basin Development Authority, prepared an Environmental Impact Statement according to the legislation's "General Guidelines for the Preparation of an Environmental Impact Statement";

- the proponent conducted a public participation program in Saskatchewan, the EIS was reviewed by the Saskatchewan Department of Environment and by a Board of Inquiry which held public hearings in Saskatchewan, and

- the Minister issued approval under the Saskatchewan EA Act on the advice of Department of Environment staff and the Board of Inquiry (Appendix 2).

The Saskatchewan EIA dealt only with potential impacts in Saskatchewan.

THE CANADIAN INTERNATIONAL RIVER IMPROVEMENTS ACT

To construct, operate and maintain any "international river improvement" (any works which may affect the flow regime of an international waterway) a license from the Minister of Environment is necessary under the International River Improvements Act (R.S.C. 1970 c. I-22). The Act requires that the Minister address areas of federal responsibility (transboundary water flows, fish, migratory waterfowl) and permits the Minister to attach appropriate conditions to the license to meet federal obligations. The licensing process included the following steps:

- the Souris Basin Development Authority submitted an application to Environment Canada,
- Environment Canada technical staff reviewed the application and made recommendations to the Minister, and
- the Minister issued the license for the project (Appendix 3).

The granting of this license permits the start of construction of the Rafferty and Alameda dams. In the absence of U.S. funding for the project, and as long as the project retains no more than 50% of the annual natural flow originating in Saskatchewan and does not contravene the Boundary Waters Treaty of 1909, the IRIA license and approval under the Saskatchewan Environmental Assessment Act provide authorization for the construction and operation of the dams.

THE UNITED STATES NATIONAL ENVIRONMENTAL POLICY ACT

The U.S. National Environmental Policy Act of 1969 requires the preparation of a detailed statement of potential impacts when a major federal action might significantly affect the quality of the human environment or cause an irreversible commitment of resources. The Act cannot be viewed as a licensing process, but it does provide authority to approve a project; require additional information to ensure adequate environmental assessment; oppose a project based on ecological factors. The Environmental Protection Agency, while not generally authorized to stop a project, may use its influence with other federal authorities to oppose a given project.

As required under NEPA, the following actions have occured.

- The proponent, the U.S. Army Corps of Engineers, prepared a draft EIS which was released to the public and discussed with other interested U.S. federal and state agencies.
- A public meeting was held in Minot to discuss the proposal.
- The proponent prepared a "final" EIS which was released to the public and formally reviewed by the U.S. Environmental Protection Agency (EPA).

- The EPA set out requirements for additional information which it considers necessary to provide an adequate environmental assessment of the project.

The EPA review of the Final EIS is attached as Appendix 4. How the Corps of Engineers will deal with the recommendations for additional information has not yet been determined.

CANADA-UNITED STATES AGREEMENT

An international agreement is required to allow for the flow of U.S. funds to Saskatchewan; provide for an operating plan in the Souris River basin and ensure flood protection; provide for certain measures relating to water quality; provide for compensation to Manitoba should damage occur; and generally to allow for co-operative water management in the Souris River Basin.

III

WATER QUANTITY

A wide range of water quantity data is available for the Souris River in Saskatchewan, North Dakota, and Manitoba. The Souris River Board of Control is responsible for monitoring flow apportionment on the river. The U.S. Fish and Wildlife Service has operated a series of wildlife refuges on the river in North Dakota for many years, and many communities and rural residents draw their water from the river. To meet the demands for flow information there are currently 79 hydrometric stations in operation in the Souris River basin. The stations are listed in tables 1 to 3 of this section.

Data is also available from previous studies. The Souris Basin Study was a joint water management study carried out by Canada, Saskatchewan, and Manitoba in the mid-seventies. Natural flow data, or flows that would have occurred in the absence of man, were developed during the Souris Basin Study. Natural flow data provides a basis for comparisons of flows under altered conditions and water uses. Evaporation estimates prepared for that study were used in the flow simulations for the present impact analysis. The analytical method used for assessing agricultural flood damages were also taken from the Souris River Basin study.

The impact analysis approach was largely fashioned after that used by the Burlington Dam Task Force and the Lake Darling Task Force. These two international technical committees reported to a standing committee of the International Joint Commission.

Appendix 7 provides a detailed hydrologic assessment of the impact of the proposed Rafferty and Alameda Project on flows and flooding in Manitoba. The flow data simulated for post-project conditions were not contained in any of the reports prepared by the project proponents, but were received directly from the U.S. Army Corps of Engineers and from the North Dakota State Water Commission. The flow files were carefully reviewed by Manitoba hydrologists and a few adjustments were made to more accurately reflect flows that would be released to Manitoba during drought conditions. With these changes the flow files are considered to be a reasonable representation of flows that would occur in Manitoba after the project is in place for a hydrologic period similar to the 63 year period from 1912 to 1974.

FLOOD IMPACT

The Souris River in Manitoba is very prone to flooding. The reach north of the International Boundary starts flooding at a flow of 150 cfs. Further downstream flooding starts between 1000 and 1500 cfs. The simulations detailed in Appendix 7 show that for most flood years the project operation would have little impact on the peak flow in Manitoba, but flood waters would recede much more quickly, thereby permitting earlier seeding of crops after a flood. The analysis indicated that, in terms of agricultural and urban flooding, there would be an annual net benefit. These results are not unexpected. The project is designed to retain flood waters and to release them slowly over the summer. The peak flow would seldom be affected because the peak on the Souris River in Manitoba is normally caused by runoff from the portion of the watershed downstream from Minot, North Dakota. The later arrival of flood flows from western North Dakota and Saskatchewan tends to prolong the flooding in Manitoba. If these flows are reduced by the project, flows in Manitoba will recede to normal summer levels more quickly.

FLOW REGIME CHANGES

Although flooding is a persistent problem on the Souris River, low flows are also a matter of concern. With the Rafferty-Alameda project in place Saskatchewan would be able to store and utilize a much higher percentage of the flows arising in Saskatchewan. Average annual flows are given for natural, historic, and post-project conditions in Appendix 7. The data indicates that under natural conditions 28 percent of the flows recorded at Wawanesa arose in Saskatchewan, 41 percent arose in North Dakota, and 31 percent originated in Manitoba. The tabulation verifies that Saskatchewan will use considerably more water once the project is in place. Because of the reduced flows passed to North Dakota the State will use less water.

The simulations also indicate that the flow pattern over the year will also be changed by the project. With the large storage capacity created by the dams the frequency of occurrence of flood flows in Manitoba would be reduced. As these stored flows are then released over the summer, normal summer flows in Manitoba would be increased. Average winter flows would be similar to historic. Figure 1 shows the average monthly flows for historic and for post-project conditions. The data indicates that average flows would be lower in April to June and higher over the rest of the summer.

The analysis detailed in Appendix 7 is predicated on the assumption that the project will be operated in accordance with the operating rules which have been tentatively agreed to by the project proponents. Changes in operation, particularly with respect to the pre-flood drawdown of the reservoirs could significantly alter the impact of the project on Manitoba. To protect Manitoba's interest Manitoba must ensure that there is consultation and cooperation among all agencies concerned before any operational changes are implemented. Regular liaison with flow forecasters in Manitoba at the end of the winter season would ensure that the reservoir drawdown before the runoff begins will not aggravate flooding in Manitoba.

Table 1

ACTIVE HYDROMETRIC STATIONS - SOURIS RIVER IN SASKATCHEWAN
(Stations are operated by WSC, Regina, unless otherwise noted)

Station No.	Station Name
05NB025	Souris River near Lewvan
05NB031	Souris River near Bechard
05NB030	Souris River near McTaggart
05NB017	Souris River near Halbrite
05NB009	@Souris River near Roche Percee
05ND001	Souris River near Glen Ewen
05NB011	Yellowgrass Ditch near Yellowgrass
05NB018	Tatagwa Lake Drain
05NB014	Jewel Creek near Goodwater
05NA005	Gibson Creek near Radville
05NA004	Long Creek near Maxim
05NA003	Long Creek at Western Crossing of International Boundary
05NB001	Long Creek near Estevan
05NB021	Short Creek near Roche Percee
05NC001	Moose Mountain Creek below Moose Mountain Lake
05ND004	@Moose Mountain Creek near Oxbow
05NF010	Antler River near Wauchope
05NF006	Lightning Creek near Carnduff
05NF013	Gainsborough Creek near Storthoaks
05NC006	Arcola Index Reservoir
05NB012	Boundary Reservoir near Estevan
05ND006	Frobisher Index Reservoir
05ND009	Kenosee Lake near Carlyle
05NC002	Moose Mountain Lake (Reservoir) near Corning
05ND008	White Bear (Carlyle) Lake near Carlyle
05NB029	Dead Lake Project - Souris River Channel
05NB022	Dead Lake Reservoir near Midale
05NA006	Larsen Reservoir near Radville
05NA009	Radville Index Reservoir
05NB016	Roughbark Reservoir near Weyburn
05NB024	Weyburn Index Reservoir
05NB020	Nickle Lake near Weyburn
05NE002	Moosomin Lake near Moosomin
05NE001	Pipestone Creek near Moosomin

@ Stations equipped with data collection platforms (DCP) for real-time data.

Table 2

ACTIVE HYDROMETRIC STATIONS - SOURIS RIVER IN NORTH DAKOTA
(Stations are operated by USGS, unless otherwise noted)

Station No.	Station Name
05114000	+Souris River near Sherwood
05116000	+Souris River near Foxholm
05117500	+Souris River above Minot
05120000	@Souris River near Verendrye
05122000	+Souris River near Bantry
05124000	+Souris River near Westhope
05113600	$Long Creek near Noonan
05116500	$Des Lacs River at Foxholm
	Bonnes Coulee near Velva (high flow measurement only)
05120500	Wintering River near Karlsruhe
05123400	Willow Creek near Willow City
05113750	East Branch Short Creek Reservoir near Columbus
05115500	*Lake Darling near Foxholm
05123000	Lake Metigoshe near Bottineau
	*Dam No. 320 on Souris River
	*Dam No. 326 on Souris River
	*Dam No. 332 on Souris River
	*Dam No. 357 on Souris River
05123510	+Deep River near Upham
05123900	Boundary Creek near Landa
05123500	Stone Creek near Kramer
05123750	Cutbank Creek at Upham

\+ Stations equipped with telemarks for real-time data.

@ Stations equipped with data collection platforms (DCP) for real-time data.

$ Stations equipped with BDTs for real-time data.

* Stations operated by the Fish and Wildlife Service.

Table 3

ACTIVE HYDROMETRIC STATIONS - SOURIS RIVER IN MANITOBA
(Stations are operated by WSC, Winnipeg, unless otherwise noted)

Station No.	Station Name
05NF016	@Souris River near Coulter
	*Souris River near Napinka (April to October only)
05NG025	Souris River on P.R. 345 near Lauder
	*Souris River near Hartney (April to October only)
05NG021	Souris River at Souris
05NG001	+Souris River at Wawanesa
05NF014	Waskada Creek near Cranmer
05NG020	Medora Creek near Napinka
05NG012	Elgin Creek near Souris
05NF002	Antler Creek near Melita
05NF007	Gainsborough Creek near Lyleton
05NF008	Graham Creek near Melita
05NG007	Plum Creek near Souris
05NG003	Pipestone Creek near Pipestone
05NG024	#Pipestone Creek near Saskatchewan Boundary
05NF015	Jackson Creek near Melita
05NG019	Stony Creek near Broomhill
05NG016	Turtlehead Creek above Deloraine Reservoir
05NG010	Oak Creek near Stockton
05NG014	Deloraine Reservoir
05NG023	Whitewater Lake near Boissevain
05NG008	Oak Lake at Oak Lake Resort

@ Stations equipped with data collection platforms (DCP) for real-time data.

* Operated by MWRB.

+ Stations which have telemetry for real-time data.

Operated by WSC, Regina.

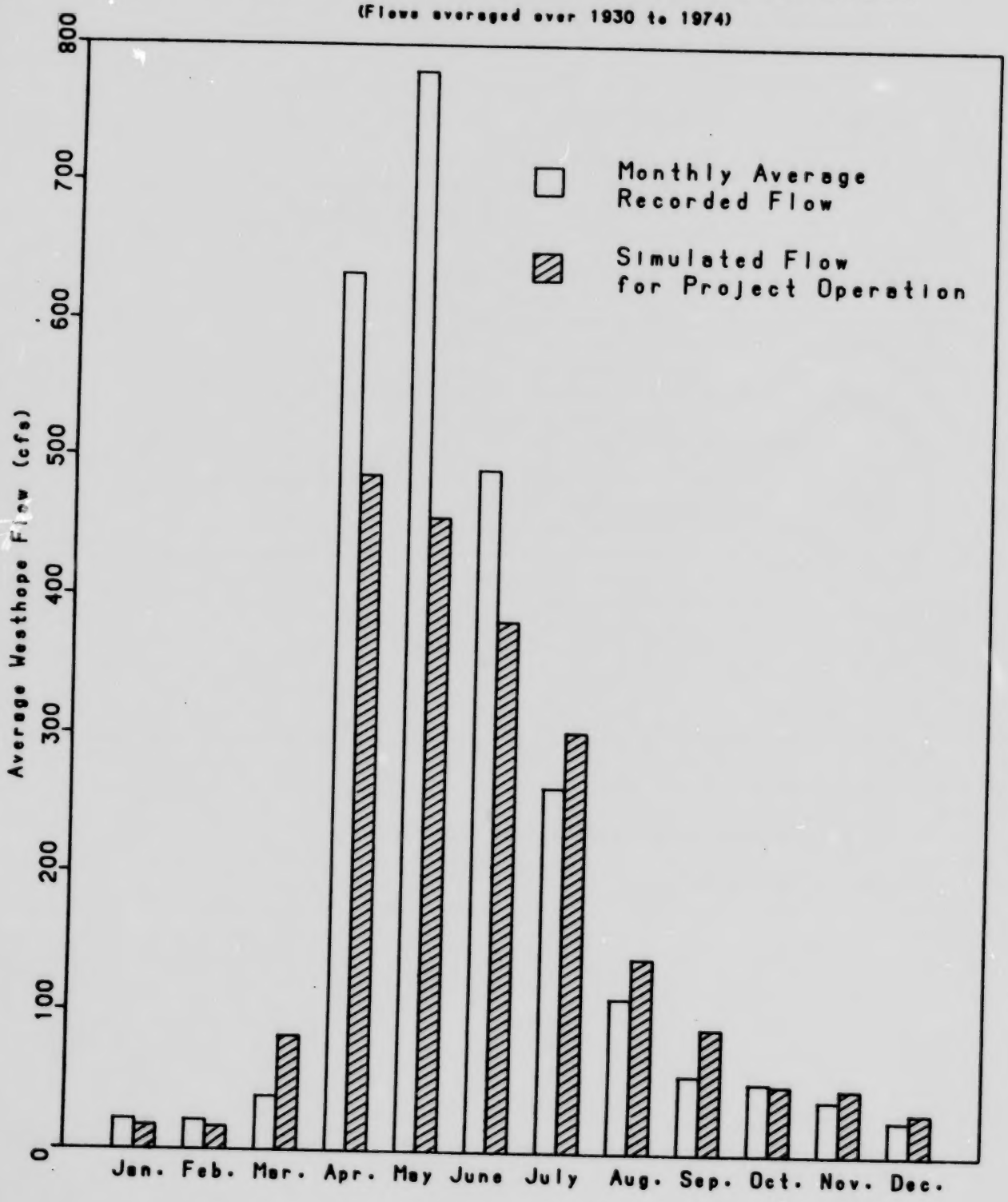

Average Flows at Manitoba Border for Historic and Post-Project Conditions
(Flows averaged over 1930 to 1974)
Monthly Average Recorded Flow
Simulated Flow for Project Operation
Average Westhope Flow (cfs)
0
100
200
300
400
500
600
700
800
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.

FIGURE 1

IV

WATER QUALITY

For a project of this nature (one which creates reservoirs and alters flows), there are a number of potential downstream water quality impacts which could occur. Broadly categorized these are: a decrease in downstream flows may result in an increase in the concentration of constituents which enter downstream; chemical substances may enter the water as a result of new or expanded water uses; physical changes may occur; and biological changes may occur downstream due to changes in the flow regime. The available assessment information was examined to analyse these types of water quality effects, particularly for the Manitoba reach of the Souris.

A major feature of the Souris River basin upstream of Manitoba is the high degree of flow control already in place in North Dakota. Lake Darling is the major reservoir and dam site, while downstream there are five smaller dams. Any flow change in the upper portion of the river basin necessitates changes in the operation of control structures throughout the system. The system is complex and no single alteration to it can be considered in isolation.

There are a number of useful analytical models used for predicting future water quality conditions in and downstream of impoundments. However, each model has its limitations and is only as good as the data available to drive it. The more complex the system (such as a series of reservoirs along hundreds of miles of river), the less reliable the model. Nevertheless, the models perform fairly well when examining specific physical and chemical parameters. On the other hand, modelling biological behavior under varying flow regimes is not nearly as well developed.

Although flow on the Souris has been apportioned by international agreement, this apportionment occurred in a time when water quality was not a prominent concern. The apportionment agreements do not specifically reference water quality, therefore it must be assumed that the Boundary Waters Treaty continues to apply and no jurisdiction can exercise its apportionment rights at the expense of another jurisdiction's water quality.

Any analysis of the possible effects of the Rafferty/Alameda dams project on Manitoba water quality must take into account the following factors:

- The Rafferty dam is located approximately 640 kilometers upstream of the Manitoba/North Dakota border.

- Only about 35% of the total natural flow in the Souris River Basin originates in Saskatchewan.

- There is a major reservoir and control structure (Lake Darling) and several smaller dams and impoundments in North Dakota which now controls the quantity of water which will reach Manitoba and which will continue to do so after the Rafferty/Alameda project is in place.

MANITOBA WATER QUALITY OBJECTIVES

Manitoba has had, since 1978, use-related water quality objectives for all significant parameters, and a process for assigning the objectives to Manitoba's nineteen principal watersheds according to the water uses to be protected. One of these basins is the Souris River Principal Watershed, for which water quality objectives were developed and, after extensive public hearings by the Manitoba Clean Environment Commission, were adopted in 1980. The objectives for the Souris River Basin in Manitoba are attached as Appendix 12.

These water quality objectives will be useful in assessing the possible impact on Manitoba of any upstream developments on the river system provided that the following factors are kept in mind;

- water quality objectives represent a desired in-stream water quality but they are not "standards" to be applied directly to regulate site-specific developments; because of in-stream mixing and background water quality, site specific standards are often higher than the objectives.

- the objectives take into account actual, historic water quality and existing water uses and hence are not intended to impose unrealistic or unattainable water quality goals.

- in setting its objectives for the Souris River, Manitoba has assumed that the quality of water it receives from North Dakota will continue to remain within historic ranges.

THE SOURIS BASIN DEVELOPMENT AUTHORITY ENVIRONMENTAL IMPACT STATEMENT AND SUPPLEMENTARY STUDIES

Chapter 8 (227 pages) of the Souris Basin Development Authority EIS for the Rafferty-Alameda project addresses the subject of water quality impacts as required under the Saskatchewan Environmental Assessment Act. The assessment addresses water quality implications within the province of Saskatchewan only. Saskatchewan recognizes that potential impacts to Manitoba must be addressed but contends that it is the responsibility of the U.S. Army Corps of Engineers to do so in its U.S. project EIS. Whether one accepts this contention or not, an analysis of water quality at the Saskatchewan-North Dakota boundary is useful in assessing possible impacts to Manitoba.

After reviewing the SBDA EIS material technical staff from North Dakota, Manitoba, and Canada agreed that there was insufficient information and analysis to present a complete picture of post-project water quality at the Saskatchewan-North Dakota border. The EIS lacked adequate documentation regarding the models and data used and further analysis for several physical, chemical and biological parameters was required. As a result the SBDA prepared a supplementary water quality analysis report entitled "Proposed Rafferty and Alameda Reservoirs - Souris River Water Quality at the Saskatchewan/North Dakota Boundary".

The results of the study confirm that there will be degradation of water quality immediately downstream of the project. Recovery for most parameters can, however, be expected by the time the flow reaches the Saskatchewan/North Dakota boundary.

The salient features of the SBDA assessment material are:

- for the parameters studied, water quality at the Saskatchewan/North Dakota boundary meets Manitoba's Souris River water quality objectives for most conditions. There is some uncertainty concerning ammonia levels and it appears that North Dakota's ammonia standards could be exceeded.

- the supplementary report addressed the specific items requested by Manitoba. The models used appear to employ the best scientific information available concerning the nature of the various processes which affect each parameter assessed.

- U.S. Environmental Protection Agency modeling has confirmed the general validity of the model employed; results relating to dissolved oxygen from both models agree but the United States Environmental Protection Agency predicts somewhat higher ammonia levels.

- There are some aspects of the Saskatchewan analysis which could not produce definitive answers:

    * the estimated travel time of flow from the project to the Saskatchewan-North Dakota border is critical to water quality predictions and is subject to conflicting assumptions. Future instream weirs for irrigation will affect travel time in an as yet unknown fashion.

    * pesticide runoff has been estimated as well as can be done at present but remains a function of future unknown actions (acreage irrigated, types and quantities of pesticides used).

    * what will occur during the reservoir filling period is still uncertain.

    * potential for change in the major ion characteristics of the flow remains high and further modeling for a period of dry years should be carried out.

- the Saskatchewan assessment addresses water quality only within its own provincial boundaries. Even if water quality at the Saskatchwan/North Dakota border meets all of Manitoba's objectives there remains a potential for impact to Manitoba because of changes to the flow regime which could alter water quality in North Dakota and/or which could trigger biological changes in the Manitoba reach of the Souris.

The Manitoba and Canadian evaluations of the Souris Basin Development Authority supplemental water quality analysis are contained in Appendices 8 and 9 respectively.

INTERNATIONAL RIVER IMPROVEMENTS ACT

Manitoba was not directly involved in the federal government licensing process under the International River Improvements Act, however, there were some informal discussions between technical staff from Manitoba, Saskatchewan and Environment Canada relating to the terms of the license. The sections of the license relevant to Manitoba's interests are clauses two, three, four, five and ten (Appendix 3).

Clause 2 binds the project to the terms of any international agreement that Canada negotiates with the United States on the project including such clauses as relate to Manitoba interests.

Clause 3 ties the project's requirements to amend existing flow apportionment on the Souris, to overall flow apportionment (ie. IJC 1959 Interim Measures) and provides a basis for Manitoba's concerns to be included in any renegotiated apportionment.

Clauses 4 and 5 confirm the concept of water quality objectives and follow-up monitoring as the appropriate vehicle for dealing with multi-jurisdictional water quality issues. This paves the way for application of the same principle at the North Dakota/Manitoba boundary.

Clause 10 reaffirms that the Boundary Waters Treaty of 1909, which provides protection for Manitoba's water quality at the international boundary, is in no way diminished by the apportionment of water quantity.

THE UNITED STATES ARMY CORPS OF ENGINEERS ENVIRONMENTAL IMPACT STATEMENT

The Souris Basin Development Authority has taken the position that, as major water quality impacts are not expected at the Saskatchewan/North Dakota boundary, any impacts to Manitoba will result from systems operation in North Dakota and therefore analysis of such potential impacts can only be conducted on the U.S. reach of the Souris.

The U.S. Army Corps of Engineers is addressing project environmental impacts in the U.S. as outlined in Section III of this report. The Corps filed a draft EIS in November of 1987 which was reviewed by Manitoba. The Province's technical response, presented in Appendix 10, reiterated Manitoba's position that its concerns must be incorporated into the U.S. documentation in the form of an assessment of post project water quality at the North Dakota/Manitoba border as a result of the collective changes to the regulation of flows into Manitoba; and that possible biological changes in the lower Souris as a result of flow changes must also be addressed.

The Corps of Engineers filed its final EIS in July 1988. The response to Manitoba's concerns are contained in the following paragraph:

> "The analysis of impacts of the flood control project on water quality are presented in paragraphs 5.09 - 5.11 and 5.43 - 5.60 of the final EIS. We believe the majority of potential water quality concerns associated with the Saskatchewan reservoirs will occur during non-flood period and would occur with or without the flood control project. We believe the proper avenue for undertaking a study such as you suggest would be with the Province of Saskatchewan and the State of North Dakota. In correspondence dated 29 February 1988 the North Dakota Department of Public Health assurred Manitoba that they would do everything within their power to insure that Section IV of the Boundary Waters Treaty Act is met." (COM-56)

In addition, the U.S. Fish and Wildlife Service stated in Appendix 2 (page 40) to the EIS:

> "The final concern expressed is the effect of the project on the water quality leaving the U.S. for Manitoba. It is expected that if the Salyer pools degrade quality in the form of increased nutrient loading as a result of the project, the effect on Manitoba will be similar. The Boundary Waters Treaty calls for non-degradation of water passed to Canada. This requirement may not be satisified with the decreased flow regimes."
>
> "The full impact of the project on the water quality of the Souris River in North Dakota is not known. It is expected that, due to the change in the hydrologic characteristics of the basin under a 50/50 apportionment and flood control operation, water quality will be degraded."

The United States Environmental Protection Agency review of the final EIS released in September, 1988 (Appendix 4) pointed out deficiences which will have to be remedied by the Corps to complete the EIS. The EPA raises the following concerns:

- EPA modeling indicated that as a result of the Rafferty/Alameda project future flow from Saskatchewan may have ammonia levels exceeding North Dakota's water quality standard for this parameter.

- The Corps' "base case" against which impacts were measured was with the Rafferty/Alameda project in place. In other words the Corps contends that Saskatchewan will build the project anyway and therefore whatever direct impacts occur therefrom will occur anyway and need not be assessed. The EPA wants further documentation of this contention.

- EPA stresses the need for the establishment of an on-going multi-jurisdictional Water Quality Board for the Souris River basin. It endorses the principle that there should be basin-wide management of the river so that should any adverse impacts arise from the regulation of flows the system can be adjusted to mitigate such impacts.

- EPA recommends that all U.S. and international agreements required for the project be completed and signed before a final commitment is made to the project.

REVIEW OF EXISTING WATER QUALITY DATA AND MONITORING

The Souris River has received some attention with respect to water quality studies and routine monitoring. The following list is a compilation of published water quality reports dealing with the Souris River:

Beck, A.E. 1981. A Report on the 1980 Cladophora Bloom on the Souris River. Environmental Management Division. Manitoba Department of Consumer and Corporate Affairs and Environment. 25 pp.

Blachford, D.P. 1987. Data Evaluation for Objectives Development for the Souris River Basin. Volume 1 and Volume 11. Water Quality Branch. Environment Canada. 132 p and Appendices.

Chacko, V. 1986. Nutrient Characteristics of the Souris River at Coulter, Manitoba, During Low Flow Years. Inland Waters Directorate. Environment Canada. 14 pp.

Environmental Protection Agency, 1971. Water Quality Investigations, Souris River Basin, North Dakota, 1969. Water Quality Office, Region VII, Kansas City, Missouri.

Environmental Management Division, 1980. Report on a Proposal for the Classification of Manitoba's Surface Water, Souris River Principal Watershed Division. Manitoba Clean Environment Commission.

McDonald, R.A. and H. R. Hamilton. 1988. Proposed Rafferty and Alameda Reservoirs. Souris River Water Quality at the Saskatchewan/North Dakota Boundary. Souris Basin Development Authority. 112 pp.

Munro, D., R. Crosley, 1983. Souris River Automatic Water Quality Monitoring, 1977-1982. Report 1: Preliminary Data Interpretation. Water Quality Branch, Environment Canada. WQB-WNR-83-03. April, 1984.

North Dakota State Game and Fish Department, 1977. Ecological Investigations of Lakes, Streams and Impoundments in North Dakota (Surveys) Dingell-Johnson Division, Project F-2-R-23, Study II, Jobs IIA and IIB. Report No. A-1046.

Souris River Basin Study Board. 1978. Souris River Basin Study. Supplement 4. Water Quality.

Souris Basin Development Authority. 1987. Rafferty-Alameda Project Environmental Impact Statement. Chapter 8. Water Quality. Souris Basin Development Authority. 228 pp.

United States Department of the Interior, 1976. Limnological Survey of the Souris River and its Major Tributaries in North Dakota, October 1975. By R.A. Ulrich, F.K. Pfeifer, Fish and Wildlife Service, Bismark, North Dakota.

In addition to previously published studies there are data available on a wide variety of water quality parameters at a number of locations in the Souris River basin gathered over a number of years.

Blachford, (1987) identified at least five agencies which collect and analyze water quality information on the Souris River. These agencies are:

Water Quality Assessment Section, Saskatchewan Department of Environment.

Environmental Management Services Branch, Manitoba Department of Environment and Workplace Safety and Health.

Division of Water Supply and Pollution Control, North Dakota State Department of Health.

Water Quality Branch, Environment Canada

United State Geological Survey.

Blachford (1987) determined that data were available for seventeen sites in the North Dakota portion of the Souris (11 Geological Survey, 6 Department of Health), eleven sites in Saskatchewan (10 Saskatchewan Department of Environment, 1 Environment Canada) and four sites in Manitoba (3 Department of Environment and Workplace Safety and Health, 1 Environment Canada). This data base is summarized in Table 1 which has been extracted from Blachford (1987).

The current water quality monitoring in Manitoba consists of monthly monitoring by Environment Canada at Coulter and monthly monitoring by Manitoba Environment and Workplace Safety and Health at Treesbank. Table 2 lists the parameters being monitored and the frequency of sample collection. In addition to water, fish are monitored annually for heavy metal and organic accumulation (Table 3) near the Town of Souris by Manitoba Environment and Workplace Safety and health.

The Department of Environment and Workplace Safety and Health maintains a water quality data base which includes the Souris River data from the Manitoba portion of the river.

Environment Canada maintains a water quality data base (NAQUADAT) which includes the data for the two federal monitoring stations at Coulter, Manitoba and Glen Ewan, Saskatchewan.

Saskatchewan Department of the Environment maintains a water quality data base which includes the data collected of the sampling locations on the Souris River within Saskatchewan.

The data from water quality monitoring stations on the Souris River in North Dakota is stored in the federal United States Geological Survey data base (STORET).

Although there have been a few previous studies related to biological water quality on the Souris River it is clear from the above review that no comprehensive examination of this subject has been undertaken to date. Appendix 11 presents a preliminary research proposal developed cooperatively by staff of the Manitoba Department of Environment and Workplace Safety and Health and the University of Manitoba.

TABLE 1. SITE DESCRIPTION AND DATA COLLECTION HISTORY FOR SELECTED SITES

AGENCY	SITE	CODE (HAQUADAT, AGENCY CODE)	PERIOD OF RECORD	NUMBER OF SAMPLES
ENVIRONMENT CANADA				
	Souris River at Coulter	05OHA05HF0001	1960-1986	2193
	Souris River at Glen Ewen	05OSA05HD0001	1960-1985	403
SASKATCHEWAN DEPARTMENT OF ENVIRONMENT				
	Souris River, Above Weyburn 2m NW	05OSEK01100001	1977-1982	9
	Souris River, Below Weyburn on #39 Hwy	05OSEK01100002	1977-1982	10
	Souris River, Below Wickle Lake	05OSEK01100003	1978-1982	20
	Souris River, West of Melbrite	05OSEK01100004	1978-1981	20
	Souris River, No. 18 Hwy near Estevan	05OSEK01100005	1974-1986	76
	Souris River, No. 47 Hwy at Estevan	05OSEK01100006	1978-1986	44
	Souris River, Below Estevan Sewage Inflow	05OSEK01100007	1974-1986	5
	Souris River, No. 39 Hwy at Roche Percee	05OSEK01100008	1978-1982	27
	Souris River, No. 9 Hwy South of Alameda	05OSEK01100009	1971-1981	16
	Souris River, Near Glen Ewen	05OSEK01100010	1978-1981	19
NORTH DAKOTA STATE DEPARTMENT OF HEALTH				
	Souris River - North of Sawyer	05USO5MD0012,380050	1973-1986	83
	Souris River - Minot	05USO5MD0013,380020	1958-1973	61
	Souris River - Towner	05USO5MD0014,380018	1968-1986	183
	Des Lacs River - Foxholm	05USO5MD0015,380021	1968-1986	46
	Souris River - Kramer	05USO5MD0016,380078	1977-1986	102
	Souris River - Westhope	05USO5MD0017,380019	1968-1974	72
UNITED STATES GEOLOGICAL SURVEY				
	Souris River near Verendrye	05USO5MD0001,05120000	1949-1986	499
	Wintering River near Karlsruhe	05USO5MD0002,05120500	1971-1984	164
	Souris River above Minot	05USO5MD0003,05117500	1969-1985	213
	Des Lacs River at Foxholm	05USO5MD0004,05116500	1949-1984	196
	Souris River near Foxholm	05USO5MD0005,05116000	1971-1984	213
	Souris River near Sawtry	05USO5MD0006,05122000	1970-1985	181
	Willow Creek near Willow City	05USO5MD0007,05123400	1959-1984	120
	Deep River below Cut Bank Creek	05USO5MD0008,05123760	1975-1982	34
	Boundary Creek near Lands	05USO5MD0009,05123900	1971-1981	68
	Souris River near Sherwood	05USO5MD0010,05114000	1978-1985	255
	Souris River near Westhope	05USO5MD0011,05124000	1954-1985	573
MANITOBA DEPARTMENT OF ENVIRONMENT AND WORKPLACE SAFETY AND HEALTH				
	Souris River at PTH 22 at Souris	05OMW05MG0171	1978-1983	51
	Souris River at PR 334 at Wawanesa	05OMW05MG0388	1978-1984	70
	Souris River at Treesbank	05OMW05MG0150	1965-1986	94

TABLE 2(a) Water quality parameters being monitored near Treesbank on the Souris River. Manitoba Environment and Workplace Safety and Health. The monitoring is monthly unless otherwise specified.

pH	manganese (q)
conductivity	iron (q)
temperature	potassium
turbidity	sodium
fecal coloform	chloride
non-filterable residue	sulphate
filterable residue	2,4-D (q)
alkalinity (total)	lindane (q)
alkalinity (HCO_3	bromoxynil (q)
dissolved oxygen	triallate (q)
total organic carbon	trifluralin (q)
total inorganic carbon	diclofop-methyl (q)
colour (true)	
total Kjeldhal nitrogen (dissolved, particulate and total)	
nitrate-nitrite nitrogen (dissolved, particulate and total)	
total phosphorus (dissolved, particulate and total)	
ammonia	
arsenic (total) (q)	propanil (q)
boron (dissolved) (q)	picloram (q)
cadmium (extractable (q)	dicamba (q)
copper (extractable) (q)	MCPA (q)
lead (extractable) (q)	simazine (q)
nickel (extractable) (q)	
zinc (extractable) (q)	
chromium (hexavalent) (q)	
calcium	
magnesium	
hardness	

q = quarterly

TABLE 2(b) Water quality parameters being monitored near Coulter on the Souris River (Environment Canada). The monitoring is monthly unless otherwise specified:

pH		calcium	
conductivity		magnesium	
temperature		fluoride	
turbidity		potassium	
fecal coliform		sodium	
total coliform		chloride	
fecal streptococcus		silica	
non-filterable residue		sulfate	
filterable residue		cadmium (total)	
alkalinity		cobalt (total)	
dissolved oxygen		nickel (total)	
particulate organic carbon		copper (total)	
dissolved organic carbon		lead (total)	
colour (true)		zinc (total)	
total dissolved nitrogen		barium (total	
particulate nitrogen		vanadium (total)	
ammonia nitrogen		iron (dissolved)	
nitrate-nitrite nitrogen		manganese (dissolved)	
total phosphorus		selenium (dissolved)	
orthophosphorus		cyanide (total)	
radionuclides		mercury (total)	
*uranium	(q)	boron (dissolved)	
*tritium	(q)	aluminum (dissolved)	
*antimony	(q)	caluminum (extractable)	
*cesium	(q)		
2,4-D	(q)	endevan	(q)
2,4-DP	(q)	hexachlorobenzene	(q)
2,4-DB	(q)	alpha-BHC	(q)
2,4,5-T	(q)	lindane	(q)
MCPA	(q)	methoxychlor	(q)
MCPB	(q)	PCB (total)	(q)
dicamba	(q)	phenolics	(q)
2,3,6-TBA	(q)		
trifluralin	(q)		
triallate	(q)		
diclofop-methyl	(q)		
diallate	(q)		
atrazine	(q)		
barban	(q)		

Q = Quarterly

TABLE 3. Fish parameters being monitored annually near Souris on the Souris River, by Manitoba Environment and Workplace Safety and Health.

METALS	ORGANICS
mercury	arochlor - 1248 (PCB)
copper	arochlor - 1254 (PCB)
lead	arochlor - 1260 (PCB)
zinc	aldrin
nickel	chlordane (total)
cadmium	dieldrin
chromium	endrin
selenium	methoxychlor
arsenic	total DDT
	DDT isomers
	DDT isomers
	DDT isomers
	BHC (4 isomers of lindane)
	heptachlor
	heptachlor expoxide
	endosulfan
	mirex

V

CONCLUSIONS

Based on the review of water quantity and quality information as outlined in Sections III and IV of this report, the Interdepartmental Committee has drawn the following conclusions.

Water Quantity

1. The information on water quantity available from the proposed system operating plan and modeling of historic flows under the proposed operating regime is adequate to assess the direct flow-related impacts on Manitoba.

2. The proposed new flow regime for the Lake Darling reservoir after the Rafferty/Alameda dams project is in place will result in net flood damage reduction benefits for Manitoba. There will be occasions, however, when flood damages in Manitoba may be higher than they would have been in the absence of the Rafferty/Alameda project.

3. Manitoba will receive less average annual volumes of water with the project in place than it would have historically received. The flow pattern will also be altered from historic patterns. There will be less flow in certain months (April to June in certain years, for example) and more flow than historically recorded in others (July to September in some years, for example).

4. The volume of water needed to meet the minimum flow guarantees for Manitoba as specified is the IJC 1959 Interim Measures will continue to be available. In other words, Manitoba will continue to receive 20 cubic feet per second of flow from June through October except under the "severe drought" conditions.

Water Quality

1. The information contained in the Souris Basin Development Authority report "Proposed Rafferty and Alameda Reservoirs; Souris River Water Quality at the Saskatchewan/North Dakota Boundary" is adequate to assess water quality impacts up to that boundary and is essential information for similar assessment work in North Dakota.

2. The SBDA report on Souris River Water Quality at the Saskatchewan/North Dakota Boundary does not directly address water quality implications of the project for Manitoba. However the projected quality at that boundary does not, in the absence of other factors (i.e. conditions in North Dakota), suggest that there will be resultant quality problems in Manitoba.

3. Since the volume of flow which reaches the Manitoba border is totally determined by the operation of control works in the State of North Dakota, and since there is one major and several smaller impoundments downstream of Rafferty/Alameda in North Dakota post-project water quality in Manitoba can only be determined by examining the full Souris River system.

4. The information contained in the U.S. Army Corps of Engineers document "Souris River Basin Project; Final Environmental Impact Statement," is not adequate to make any estimation of post-project water quality in the Souris River at the Manitoba/North Dakota boundary. This is a direct result of the Corps' position that since Saskatchewan will proceed with the project with or without U.S. funds, whatever low flow impacts occur in Manitoba are the result of Saskatchewan's retention of its authorized share of water.

5. The U.S. Army Corps of Engineers will be changing the operation of the control structure for Lake Darling (which will determine the flow and quality of water reaching Manitoba) as a direct result of its participation in the Rafferty/Alameda project. If the U.S. were not co-funding the project, the proposed operating plan which includes Lake Darling would be scrapped. The reality is that there is U.S. funding for the Rafferty/Alameda project and the project is going to result in very specific changes to Lake Darling operation, which in turn could affect Manitoba. The hypothetical "base case" offered by the Corps in no way diminishes U.S. obligations under the Boundary Waters Treaty.

6. The scientific knowledge of the biological behaviour of the Souris River ecosystem under various low flow conditions is inadequate to predict what changes, if any, may occur in biological activity in the Manitoba reach of the river under post-project conditions. At least two years of field study, perhaps more, will be required to address this concern. The water quality data base for the Souris River is otherwise adequate.

7. Given the varying reliability of the analytical tools and data available for water quality modeling, the large size of the drainage basin, the complexity of the basin with its many tributaries, control weirs and impoundments and the wide variety of possible flow control scenarios on the Souris, any post-project water quality predictions for Manitoba will necessarily have some degree of uncertainty attached to them. Regardless of the amount of pre-project analysis it will not be possible to predict with certainty water quality conditions in Manitoba.

VI

RECOMMENDATIONS

From the conclusions drawn in Section V of this report, and based on currently available information, it becomes apparent that the potential for impacts on Manitoba resulting from the construction and operation of the Souris River Basin Project is moderate. Nevertheless, the conclusions point out the necessity of continued action and diligence on the part of Manitoba to protect its interests. With this in mind, the Committee has developed a series of recommendations which take into account the following:

- Manitoba has no direct jurisdiction over the project;
- Cooperation between Manitoba and North Dakota on Souris River flows has been very good in the past;
- North Dakota's first priority for Souris River water is to supply Manitoba's entitlement under the 1959 Interim Measures;
- Canada, through the Department of External Affairs and Environment Canada, has consistently supported the position that Manitoba's concerns must be addressed in the planning and operation of the Rafferty/Alameda project.

THE COMMITTEE RECOMMENDS that the Government of Manitoba:

1. continue to insist that the proponents prepare an assessment (recognizing that there are inherent limitations) of post-project water quality on the Souris River at the Manitoba/North Dakota border. That assessment should form a part of the supplemental water quality information called for by the U.S. Environmental Protection Agency in its review of the U.S. Army Corps of Engineers Final Environmental Impact Statement.

2. initiate a scientific study of the relationship between biological behaviour and flow conditions on the Souris River in Manitoba to commence in the fall of 1988 and to continue for at least two years as outlined in Appendix 11;

3. continue to operate existing water quality monitoring stations on the Souris River and add one station to the existing network;

4. continue to pursue the establishment of a Souris River Water Quality Board with membership from Manitoba, North Dakota, Saskatchewan, Canada and the United States. The Board should be established by January 1, 1989 and begin work immediately thereafter to,

   a. develop water quality objectives for the Souris River at the international boundary crossing points,

   b. implement basin-wide water quality monitoring and assessment;

c. make recommendations with respect to management of the water flows on the Souris River to achieve the best possible water quality throughout the basin

5. continue to actively participate in negotiations to amend the IJC 1959 Interim Measures with the objective of extending minimum flow guarantees to all months of the year;

6. continue to actively pursue, as a member of the Canadian delegation, negotiation of an agreement with the United States on the Rafferty/Alameda project, to ensure that

   - all possible measures are taken so that Manitoba water quality will not be adversely impacted

   - there is a mechanism for ameliorating and mitigating any unforeseen adverse impacts to Manitoba water quality

   - Manitoba is compensated for any damages resulting from the project

   - future water management in the Souris River Basin will be conducted cooperatively between the jurisdictions on a basin-wide basis.

VII

APPENDICES

APPENDICES

1. LIST OF DOCUMENTS REVIEWED
2. SASKATCHEWAN ENVIRONMENTAL ASSESSMENT ACT MINISTERIAL APPROVAL
3. INTERNATIONAL RIVER IMPROVEMENTS ACT LICENCE
4. U.S. EPA REVIEW OF U.S. ARMY CORPS OF ENGINEERS FINAL EIS
5. BOUNDARY WATERS TREATY
6. IJC 1959 INTERIM MEASURES (SOURIS RIVER APPORTIONMENT)
7. DNR WATER QUANTITY ANALYSIS
8. MANITOBA RESPONSE TO THE SBDA SUPPLEMENTAL WQ REPORT
9. ENVIRONMENT CANADA REVIEW OF SBDA SUPPLEMENTAL WQ REPORT
10. MANITOBA RESPONSE TO U.S. ARMY CORPS OF ENGINEERS DRAFT EIS
11. MANITOBA WQ STUDY PROPOSAL
12. MANITOBA WATER QUALITY OBJECTIVES, SOURIS RIVER PRINCIPAL WATERSHED

APPENDIX 1

DOCUMENTS REVIEWED BY THE INTERDEPARTMENTAL COMMITTEE ON THE RAFFERTY/ALAMEDA DAMS PROJECT

Souris Basin Development Authority, "Rafferty-Alameda Project, Environmental Impact Statement", August, 1987.

Souris Basin Development Authority, "Proposed Rafferty and Alameda Reservoirs, Souris River Water Quality at the Saskatchewan/North Dakota Boundary", February 1988.

Zander, Bruce; U.S. Environmental Protection Agency. "Technical Review of document - Proposed Rafferty and Alameda Reservoirs, Souris River Water Quality at the Saskatchewan/North Dakota Boundary", March 1988.

Gummer, Wm. D.; Environment Canada. March 3/88 letter to Mr. George Hood, Director of Planning and Operations for the Souris Basin Development Authority commenting on the report "Proposed Rafferty and Alameda Reservoirs, Souris River Water Quality at the Saskatchewan/North Dakota Boundary".

Rafferty-Alameda Board of Inquiry, "Board of Inquiry Report", January 1988

U.S. Army Corps of Engineers, "Draft Environmental Impact Statement, Souris River Basin Flood Control Project", November 1987.

U.S. Army Corps of Engineers, "Final Environmental Impact Statement, Souris River Basin Flood Control Project", July 1988.

U.S. Environmental Protection Agency, "Detailed Comments by the EPA on the Souris River Basin Flood Control Project General Plan Report and Final Environmental Impact Statement", September 1988.

_____ "International River Improvements Act Licence", June 17, 1988.

_____ "Draft Operating Plan for Rafferty, Alameda, Boundary and Lake Darling Reservoirs", July 1988.

Manitoba Clean Environment Commission, "Report on a Proposal for the Classification of Manitoba's Surface Water - Souris River Principal Watershed Division", February 1980.

NOTE: REFER TO SECTIONS III AND IV FOR ADDITIONAL INFORMATION ON DOCUMENTS REVIEWED.

Souris Basin Development Authority, "Rafferty-Alameda Project, Environmental Impact Statement", August, 1987.

Souris Basin Development Authority, "Proposed Rafferty and Alameda Reservoirs, Souris River Water Quality at the Saskatchewan/North Dakota Boundary", February 1988.

Zander, Bruce; U.S. Environmental Protection Agency. "Technical Review of document - Proposed Rafferty and Alameda Reservoirs, Souris River Water Quality at the Saskatchewan/North Dakota Boundary", March 1988.

Gummer, Wm. D.; Environment Canada. March 3/88 letter to Mr. George Hood, Director of Planning and Operations for the Souris Basin Development Authority commenting on the report "Proposed Rafferty and Alameda Reservoirs, Souris River Water Quality at the Saskatchewan/North Dakota Boundary".

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U.S. Army Corps of Engineers, "Draft Environmental Impact Statement, Souris River Basin Flood Control Project", November 1987.

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U.S. Environmental Protection Agency, "Detailed Comments by the EPA on the Souris River Basin Flood Control Project General Plan Report and Final Environmental Impact Statement", September 1988.

_____ "International River Improvements Act Licence", June 17, 1988.

_____ "Draft Operating Plan for Rafferty, Alameda, Boundary and Lake Darling Reservoirs", July 1988.

Manitoba Clean Environment Commission, "Report on a Proposal for the Classification of Manitoba's Surface Water - Souris River Principal Watershed Division", February 1980.

NOTE: REFER TO SECTIONS III AND IV FOR ADDITIONAL INFORMATION ON DOCUMENTS REVIEWED.

APPENDIX 2

SASKATCHEWAN ENVIRONMENTAL ASSESSMENT ACT

APPROVAL FOR THE RAFFERTY/ALAMEDA DAMS PROJECT

PROVINCE OF SASKATCHEWAN

DEPARTMENT OF ENVIRONMENT AND PUBLIC SAFETY

MINISTERIAL APPROVAL

UNDER

THE ENVIRONMENTAL ASSESSMENT ACT

WHEREAS Souris Basin Development Authority (hereinafter called "the proponent") submitted to the Minister of Environment and Public Safety (hereinafter called "the Minister") an environmental impact statement entitled "Rafferty-Alameda Project Environmental Impact Statement" (dated August 4, 1987) (hereinafter called "the statement") pursuant to clause 9(1)(b) of The Environmental Assessment Act (hereinafter called "the Act") relating to the construction and operation of the Rafferty Dam on the mainstream of the Souris River six km northwest of Estevan, a channel connecting Boundary Reservoir with Rafferty Reservoir, intermittent channelization of the Souris River for sixteen kilometers downstream of the Rafferty Dam site, and the Alameda Dam on Moose Mountain Creek north of Oxbow (hereinafter called "the development");

AND WHEREAS the Minister is satisfied the proponent has met all of the requirements of The Environmental Assessment Act;

AND WHEREAS the Government of the United States of America has indicated its intention to contribute 41 million (U.S. 1985) dollars in support of the development;

NOW THEREFORE PURSUANT to clause 15(1)(a) of The Environmental Assessment Act, Ministerial Approval is hereby given to the proponent to proceed with the development subject to the following terms and conditions which form part of this Ministerial Approval:

1. i) Subject to any of the other terms and conditions contained in this Ministerial Approval, the proponent shall comply with and implement all specifications, mitigative measures and environmental protection procedures described in the statement.

ii) The proponent shall comply with all pertinent Canada and Saskatchewan legislation and regulations as same may be amended related to the construction or operation of the development. Where such legislation and regulations impose more stringent standards than those imposed by the specifications, mitigative measures and environmental protection procedures described in the statement, the proponent shall comply with the more stringent requirements of the legislation and regulations.

2. The proponent shall, prior to January 1, 1990, submit to the Minister for his approval a detailed water management plan for the Souris Basin in Saskatchewan which shall include recommendations and proposals for the implementation of mitigative measures and environmental protection procedures. This plan shall take into consideration reservoir operating procedures, flood control requirements,

human water supply demands, industrial water requirements, priorities for water uses, and ecosystem management.

3. The proponent shall acquire sufficient lands, in accordance with clauses 7 and 15 of this approval where lands are required for the replacement purposes therein described, or as otherwise may be satisfactory to the Minister where land is required for other replacement purposes in order to fulfill both the development's objectives and the measures required to mitigate the development's environmental impacts in accordance with commitments made in the statement or with other conditions of this approval. Replacement lands as herein described shall be identified in consultation with area landowners in an attempt to minimize any negative impacts upon them or their operations.

4. The proponent shall design and submit to the Minister for his approval a program to monitor water quality in the Souris Basin in Saskatchewan and shall initiate the approved program prior to January 1, 1989.

5. The proponent shall encourage the implemention of land use controls in areas surrounding the development to minimize erosion, farm chemical drainage and effluent discharge into the reservoirs.

6. Should soil salinity problems develop downstream of the dams as a result of the development the proponent shall attempt to alleviate the problems by employing remedial techniques cited in the statement. Should those techniques fail to alleviate the problems to the satisfaction of the Minister the proponent shall acquire the affected lands through the land acquisition procedures described in the statement.

7. The proponent shall replace community pasture lands which are rendered inoperable by the development on a carrying unit for carrying unit basis or as is otherwise agreed to by those responsible for the community pastures in question.

8. The proponent shall proceed with the development of a Souris Basin Park Plan as outlined in the statement, actively seek input into the development of that plan from residents of the two reservoir areas, and submit that plan to the Minister for his approval prior to its implementation.

9. The proponent shall implement the mitigative measures outlined in the statement for Dr. Mainprize Park and for the Lutheran Bible Camp when a final choice of location for the latter is made by its owners.

10. The proponent shall implement the transportation mitigation outlined in the statement and in so doing shall consult with Rural Municipalities affected by the development.

11. The proponent shall extract and stockpile for other future uses all economically extractable gravel that is surplus to that needed for the development and that is present in areas to be inundated by the reservoirs at their full supply levels.

12. The proponent shall meet, and if possible exceed, the existing regulatory standards set by Saskatchewan Energy and Mines with respect to all aspects of oil well mitigation.

13. Except where otherwise approved by Saskatchewan Energy and Mines and by the Minister, the proponent shall remove, and where necessary replace, all active pipelines and flowlines of any type, regardless of the substance they carry, from areas to be inundated by the reservoirs.

14. The proponent shall document, evaluate and salvage any significant heritage resource finds that may occur as a result of the development or activities directly related thereto, according to the requirements of Saskatchewan Parks, Recreation and Culture.

15. The proponent shall provide unit for unit (that is, no net loss) replacement of wildlife habitats which will be lost as a result of the development.

16. The proponent shall submit to the Minister for his approval plans for mitigating any negative impacts the development might have on any rare, threatened or endangered species, and shall then implement those approved plans prior to effecting such impacts.

17. The proponent shall pursue with the Minister its intent as outlined in the statement to have one or more ecological reserves established within the Souris Basin to protect typical or unique natural areas.

18. The proponent shall continue, on an ongoing basis, to work closely with wildlife organizations with the intention that the development continues to be sensitive to the needs of area wildlife.

19. The proponent shall proceed with the development of a Fisheries Management Plan for the Souris Basin and shall submit that plan to Saskatchewan Parks,

Recreation and Culture and to the Minister for their approval prior to January 1, 1990.

20. The proponent shall monitor mercury levels in fish caught in the two reservoir areas and in downstream portions of the Souris River and Moose Mountain Creek, and shall report the monitoring results to the Minister as they are obtained.

21. The proponent shall endeavour to restrict public access to clearly designated areas for viewing construction activities associated with the development.

22. The proponent shall adhere to all labour standards governing the occupational health and safety of workers.

23. The proponent shall design and undertake such additional studies of the impact of the development or of the effectiveness of mitigative measures as are proposed in the statement or as the Minister

may believe necessary, and shall implement such measures as the Minister may deem necessary to mitigate what he considers to be unacceptable adverse environmental impacts associated with the development should such impacts become apparent.

FURTHERMORE should the Government of the United States of America fail to make a commitment to contribute 41 million (U.S. 1985) dollars in support of the development, or until such time as that commitment is made, then subject to the remaining provisions and relevant conditions of this approval the proponent may proceed only with the construction of the Rafferty Dam, a channel connecting Boundary Reservoir with Rafferty Reservoir, and downstream channelization from the Rafferty Dam to a location on the Souris River near the proposed Shand Power Station.

MOREOVER this approval and the provisions and conditions thereof shall be binding upon the proponent

and upon any other person who is or who may become responsible for the development or any part thereof.

Dated at Regina, Saskatchewan this 1ST day of February, 1988.

ISSUED BY: _____

H. J. Swan

Minister of Environment and Public Safety

APPENDIX 3

THE INTERNATIONAL RIVER IMPROVEMENTS ACT LICENCE

FOR THE RAFFERTY/ALAMEDA DAMS PROJCET

INTERNATIONAL RIVER IMPROVEMENTS ACT, R.S.C. 1970 c. I-22

LICENCE

THIS LICENCE granted this 17 day of June one thousand nine hundred and eighty-eight (1988).

BY: HER MAJESTY THE QUEEN IN RIGHT OF CANADA, represented herein by the Minister of the Environment, hereinafter called "The Minister"

TO: SASKATCHEWAN WATER CORPORATION, a crown corporation of the province of Saskatchewan and having office at 111 Fairford Street East, Moose Jaw, Saskatchewan, S6H 7X9, hereinafter called "the Licensee"

WHEREAS the Licensee has filed with the Minister an application dated January 7, 1988, for a Licence under Section 6 of the International River Improvements Regulations, C.R.C. c.962, which application contains the information required by said Regulations;

WHEREAS the Licensee wishes to construct, operate and maintain international river improvements consisting of the Rafferty Dam on the mainstream of the Souris River six kilometers northwest of Estevan, the Alameda Dam on Moose Mountain Creek north of Oxbow, a tributary of the Souris River; intermittent channelization of the Souris River for sixteen kilometres downstream of the Rafferty dam and a channel connecting Boundary Reservoir with Rafferty Reservoir, in the province of Saskatchewan.

AND WHEREAS the Minister is willing to grant to the Licensee a Licence to construct, operate and maintain the above mentioned international river improvements or portions thereof (hereinafter referred to as "the improvement") pursuant to the following conditions.

1. Should the construction of any portion of the improvement, as specified in the Licensee's application of January 7, 1988, fail to proceed within seven years from the date of issuance of this Licence, this Licence shall apply only to the portion of the improvement constructed or under construction.

2. The Licensee shall comply with any obligations and responsibilities which Canada may assume under any agreement entered into with the United States in respect of the improvement, and any subsequent agreements thereto.

.../2

3. The Licensee shall meet the International Joint Commission's '1959 Interim Measures' on the Souris River flow apportionment or any subsequent amended apportionment measures adopted by the Governments of Canada and the United States.

4. The Licensee and the Minister shall develop in consultation with the other affected jurisdictions by April 1, 1990 water quality objectives for the Souris River at the international boundary, including criteria for their application, a monitoring plan and reporting requirements.

5. The Licensee shall, in consultation with the Minister, put in place a program of monitoring water quality and quantity in the areas affected by the improvement within Saskatchewan so as to provide itself with the information needed to determine if the water quality objectives and flow apportionment measures are achieved at the Saskatchewan-North Dakota boundary.

6. The costs of the required water quality and quantity monitoring activities in Saskatchewan and at the Saskatchewan-North Dakota boundary over and above those now being conducted by Canada shall be fully borne by the Licensee.

7. The Licensee, as and when requested, shall provide the Minister with information on water quality and quantity within the areas in Saskatchewan affected by the improvement.

8. The Licensee shall construct, operate and maintain the improvement so that the improvement will not cause a net loss of waterfowl productivity in the Saskatchewan portion of the Souris River Basin.

9. The Licensee shall not divert water from outside the Souris River drainage basin if such diverted waters would increase the annual flow of the Souris River at the international boundary above that which would have occurred in a state of nature.

10. The Licensee shall construct, operate and maintain the improvement in such manner as shall not contravene the International Boundary Waters Treaty of 1909.

11. The Licensee shall comply with the provisions of all federal statutes that relate to the improvement and with the relevant provisions of any regulations made pursuant to such statutes. In addition, the Licensee shall comply with the specific terms and conditions which apply to the improvement contained in the provincial Ministerial Approval under the Environmental Assessment Act of the province of Saskatchewan, dated February 13, 1988.

13. The Licensee shall at all times indemnify and save harmless the Minister from and against all claims and demands, loss, costs, damages, actions, suits or other proceedings by whomsoever made, brought or prosecuted, in any manner based upon, occasioned by or attributable to the execution of these Presents, or any action taken or things done or maintained by virtue hereof, or the exercise in any manner of the rights arising hereunder.

14. Unless a waiver is given in writing by the Minister, the Minister shall not be deemed to have waived any breach of this Licence by the Licensee.

THIS LICENCE has been granted on behalf of Her Majesty the Queen in Right of Canada acting through and represented by the Minister of the Environment to construct, operate and maintain the improvement for a term of fifty (50) years commencing on this 17 day of January, 1968, and the Licensee shall comply with the conditions herein contained which have been agreed by the Licensee as attested by the signature of its duly authorized signing officers.

GRANTED BY: HER MAJESTY THE QUEEN in Right of Canada acting through and represented by the Minister of the Environment

BY: _____

Jean Chrétien, P.C., M.P.

ACCEPTED BY: SASKATCHEWAN WATER CORPORATION

BY: _____

INTERNATIONAL RIVER IMPROVEMENTS ACT, R.S.C. 1970 c. I-22

LICENCE

THIS LICENCE granted this 17th day of June one thousand nine hundred and eight-eight (1988).

BY: HER MAJESTY THE QUEEN IN RIGHT OF CANADA, represented herein by the Minister of the Environment, hereinafter called "The Minister"

TO: SASKATCHEWAN WATER CORPORATION, a crown corporation of the province of Saskatchewan and having office at 111 Fairford Street East, Moose Jaw, Saskatchewan, S6H 7X9, hereinafter called "the Licensee"

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WHEREAS the Licensee wishes to construct, operate and maintain international river improvements consisting of the Rafferty Dam on the mainstream of the Souris River six kilometers northwest of Estevan, the Alameda Dam on Moose Mountain Creek north of Oxbow, a tributary of the Souris River; intermittant channelization of the Souris River for sixteen kilometres downstream of the Rafferty dam and a channel connecting Boundary Reservoir with Rafferty Reservoir, in the province of Saskatchewan.

AND WHEREAS the Minister is willing to grant to the Licensee a licence to construct, operate and maintain the above mentioned international river improvements or portions thereof (hereinafter referred to as "the improvement") pursuant to the following conditions,

1. Should the construction of any portion of the improvement, as specified in the Licensee's application of January 7, 1988, fail to proceed within seven years from the date of issuance of this Licence, this Licence shall apply only to the portion of the improvement constructed or under construction.

2. The Licensee shall comply with any obligations and responsibilities which Canada may assume under any agreement entered into with the United States in respect of the improvement, and any subsequent agreements thereto.

3. The Licensee shall meet the International Joint Commission's "1959 Interim Measures" on the Souris River flow apportionment or any subsequent amended apportionment measures adopted by the Governments of Canada and the United States.

4. The Licensee and the Minister shall develop in consultation with the other affected jurisdictions by April 1, 1990 water quality objectives for the Souris River at the international boundary, including criteria for their application, a monitoring plan and reporting requirements.

5. The Licensee shall, in consultation with the Minister, put in place a program of monitoring water quality and quantity in the areas affected by the improvement within Saskatchewan so as to provide itself with the information needed to determine if the water quality objectives and flow apportionment measures are achieved at the Saskatchewan-North Dakota boundary.

6. The costs of the required water quality and quantity monitoring activities in Saskatchewan and at the Saskatchewan-North Dakota boundary over and above those now being conducted by Canada shall be fully borne by the Licensee.

7. The Licensee, as and when requested, shall provide the Minister with information on water quality and quantity within the areas in Saskatchewan affected by the improvement.

8. The Licensee shall construct, operate and maintain the improvement so that the improvement will not cause a net loss of waterfowl productivity in the Saskatchewan portion of the Souris River Basin.

9. The Licensee shall not divert water from outside the Souris River drainage basin if such diverted waters would increase the annual flow of the Souris River at the international boundary above that which would have occurred in a state of nature.

10. The Licensee shall construct, operate and maintain the improvement in such manner as shall not contravene the International Boundary Waters Treaty of 1909.

11. The Licensee shall comply with the provisions of all federal statutes that relate to the improvement and with the relevant provisions of any regulations made pursuant to such statutes. In addition, the Licensee shall comply with the specific terms and conditions which apply to the improvment contained in the provincial Ministerial Approval under the Environmental Assessment Act of the province of Saskatchewan, dated February 15, 1988.

12. The Licensee shall at all times indemnify and save harmless the Minister from and against all claims and demands, loan, costs, damages, actions, suits or other proceedings by whomsoever made, brought or prosecuted, in any manner based upon, occasioned by or attributable to the execution of these Presents, or any action taken or things done or maintained by virtue hereof, or the exercise in any manner of the rights arising hereunder.

13. Unless a waiver is given in writing by the Minister, the Minister shall not be deemed to have waived any breach of this Licence by the Licensee.

THIS LICENCE has been granted on behalf of Her Majesty the Queen in Right of Canada acting through and represented by the Minister of the Environment to construct, operate and maintain the improvement for a term of fifty (50) years commencing on this 17th day of June, 1988, and the Licensee shall comply with the conditions herein contained which have been agreed by the Licensee as attested by the signature of its duly authorized signing officers.

GRANTED BY: HER MAJESTY THE QUEEN in Right of Canada acting through and represented by the Minister of the Environment

BY: _____

Tom McMillan, P.C., M.P.

SIGNED BY: SASKATCHEWAN WATER CORPORATION

BY: _____

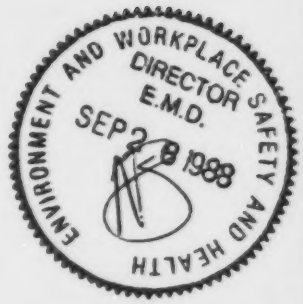
_____

APPENDIX 4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REVIEW OF "THE FINAL ENVIRONMENTAL IMPACT STATEMENT FOR THE SOURIS BASIN FLOOD CONTROL PROJECT"

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
999 18th STREET - SUITE 500
DENVER, COLORADO 80202-2405



SEP 20 1988
Ref: 8PM-EP

Colonel Roger Baldwin
District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

RE: Souris Basin Flood Control Project, Final EIS

Dear Colonel Baldwin:

In accordance with our responsibilities under the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act (CAA), the Region VIII Office of the Environmental Protection Agency (EPA) has reviewed the Final EIS for the Souris Basin Flood Control Project. The Corps is commended for its efforts to coordinate with Canada and North Dakota to respond to the flood control issues raised in the draft EIS. EPA has participated with the Corps and the U.S. State Department to include steps in the International Agreement to minimize impacts to water quality. Additional work on water quality protection is necessary before the project should proceed.

EPA is concerned about the combined Corps and Canadian proposals which may result in concentrations of un-ionized ammonia in the Souris River that exceed state water quality standards. As a result of poor water quality and the reduced flow from the reservoirs, significant fishery losses will occur in the U.S. Additional water quality documentation is necessary for the proposed action to comply with Section 313 of the Clean Water Act and the 1909 Boundary Waters Treaty. The parties involved need to assure that the water quality delivered across the border from the proposed project will not be damaging to U.S. interests. Such assurances should be provided within the proposed operational plan, International Agreement, and the upcoming agreement between the City of Minot and Saskatchewan prior to the U.S. transfer of funds to Canada for flood control.

We have noted the Corps' perspective regarding the distinction of the cumulative environmental impacts associated with the full implementation of the 1959 Interim Apportionment Agreement for the Souris River versus those impacts associated with the flood protection aspects of the project. We will notify the U.S. State Department of this issue.

We compliment the efforts by the City of Minot and the Province of Saskatchewan to include a high level outlet for the Alameda Dam which will help lower un-ionized ammonia concentrations. High level outlet releases from the Alameda Dam would provide essential operational flexibility for water quality purposes. The Corps needs to assure the agreement to fund and construct the high level outlet is completed and made part of the Record of Decision. More flexibility would be provided by multiple port outlets at both reservoirs. We suggest that the Corps should consider, as appropriate, a similar outlet for Rafferty as a water quality mitigation measure associated with the joint U.S./Canadian project.

EPA performed water quality modeling which is summarized in the Final EIS but the complete report should have been included. The EPA model relied on the inputs developed for the Souris River Basin Authority model of the Souris River. EPA's modeling predicts exceedances of state water quality standards for un-ionized ammonia concentrations at the border. Admittedly, the impacts are for atypical conditions and do not reflect long term water quality conditions. Completing the International Agreement with the intended water quality monitoring network and institution of the water quality review board, with representation from both countries, will be essential to understand and correct possible water quality impacts after project operations, and to remove uncertainties associated with current modeling predictions. Prior to the Corps' proposed action, there needs to be assurances that operational cnanges can and will be made to maintain compliance with applicable water quality standards. We suggest that Minot, in cooperation with the North Dakota Health Department, obtain such assurances as part of the agreement with Saskatchewan and that this be referenced in the International Agreement for the Souris River Project.

The final EIS lists future agreements for the proposed action which remain to be completed: 1) the operational plan for flood and non-flood operations, 2) the International Agreement to approve the 50/50 flow division, 60/40 evaporation sharing arrangement, and the installation of a water quality monitoring network and a bi-lateral water quality board, 3) compensation for project impacts to the Province of Manitoba, 4) National Wildlife Refuge mitigation agreements to provide measures to maintain refuge purposes, 5) and agreement between Minot and Saskatchewan for the high level outlet works at Alameda. In order to meet the requirements of NEPA, the Corps should complete these future agreements as essential mitigation measures before a final action is taken.

The final EIS discusses only briefly whether the predicted environmental impacts are independent actions by Canada or a result of U.S. assistance to the project. Important documents concerning this issue, including the approval by the Saskatchewan government for the project pending U.S. financial support, were not included in the Final EIS. The Final EIS acknowledges that "project developments in Canada have the potential for significant impact to fish and wildlife resources in the United States due to decreased water supply", but concludes the action of providing funds to Canada for the flood control portion of those reservoirs does not affect that result. Indeed, the low flows that are predicted to occur once the Canadian storage is large enough to contain the Canadian share are also expected to cause the loss of a $4 million U.S. fishery and the significant impact upon two waterfowl-producing wildlife refuge in the U.S. The Corps is responsible under NEPA to disclose all pertinent information for the project and its cumulative impacts regardless of who undertakes the action (40 CFR 1502.14(c) and 1508.7). Also, all mitigation measures under consideration for the entire project must be documented. This would include funding of multiple outlet works and investigation of other mitigation in addition to the list of agreements mentioned above.

EPA suggests a supplemental information document be prepared to identify the final agreements for which draft agreements are noted in the Final EIS and the potential to obtain further mitigation for the reduction in Souris River flows. Production of a supplemental information document is appropriate for the long-term, complex action under consideration to keep the public informed of the status of the proposed action as envisioned under 33 CFR 230.13(d). Again, we have noted the Corps distinction between the proposed project and the overall impacts associated with apportionment but feel it to be in the public interest to communicate all available information. In addition to completion of the mitigation measures, we suggest the supplemental information document include: 1) documentation of cumulative impacts of the proposed water supply reservoirs and the ability of the proposed action to meet the final recommendations of the Fish and Wildlife Coordination Act Report and Executive Order 12114 regarding environmental effects abroad of major federal actions, and 2) provide an analysis of low flow operations and flow augmentation opportunities in cooperation with the U.S. Fish and Wildlife Service and the U.S. State Department as appropriate under 40 CFR 1502.4(c)(1) and the Boundary Waters Treaty. The supplemental information document should be prepared prior to completion of the Record of Decision and offered for public review.

Please call me or Bob DeSpain at 303/293-1456 of my staff so that we may discuss these issues. We request a copy of the draft Record of Decision when available.

Sincerely,

James J. Scherer
Regional Administrator

cc: Senator Quentin Burdick, Bismarck
Senator Kent Conrad, Bismarck
Congressman Bryon Dorgan, Bismarck
R.A. Schemp, City of Minot, Minot
Vern Fahy, State Water Commission, Bismarck
Gene Christianson, State Health Department, Bismarck
Ed Keeton, U.S. State Department, Washington, D.C.
Galen Buterbaugh, U.S. Fish and Wildlife Service, Denver
Dale Henegar, N.D. Game and Fish, Bismarck
Bill Gummer, Environment Canada, Regina
M. Renouf, International Souris River Bd. of Control, Regina
George Hood, Souris Basin Development Authority, Regina
Jay Hair, National Wildlife Federation, Washington
Lorne Scott, Saskatchewan Wildlife Federation, Indian Head
Kenneth Brynaert, Canadian Wildlife Federation, Ottawa
Joy Wilson, U.S. EPA Federal Activities, Washington
Conrad Kleveno, U.S. EPA International Activities, Washington

Detailed Comments by the
Environmental Protection Agency
on the
Souris River Basin Flood Control Project
General Plan Report and Final Environmental Impact Statement

Water Quality Analysis

Under Section 313 of the Clean Water Act, federal agencies are obligated to comply with state and interstate requirements to control and abate water pollution unless exempted by Presidential action. In addition, under the 1909 Boundary Waters Treaty, both the U.S. and Canada are obligated to maintain water quality to prevent injury to the other party. EPA considers the U.S. payment for Canadian flood control storage and the associated low-flow operations of those reservoirs and the operational changes in Lake Darling by the Corps and the Fish and Wildlife Service to be, in combination, subject to these provisions. Operation of the reservoirs to provide compliance with state water quality standards for the critical period is required under Section 313 of the Clean Water Act and Article IV of the Boundary Waters Treaty.

The final EIS indicates that the results of EPA's water quality modeling used atypically high pH values which "renders the results highly conservative" (Final EIS-63). The final EIS could have included EPA's water quality analysis, rather than a summary of that analysis, to provide a thorough discussion for decision makers. It is appropriate to inspect critical periods of the stream rather than looking at a general condition of the stream. The most critical time, or "worst case" condition, for un-ionized ammonia at the border is during the August projections. EPA's national guidance on un-ionized ammonia standards allows excursions above the in-stream standard based upon a four-day average once every three years. Consequently, EPA modeling guidance calls for use of the 80th percentile pH value rather than the use of average or median values. A pH regime was selected for modeling purposes that considered this frequency provision. The modeling supported by the Souris Basin Development Authority (SBDA) as well as the EPA model used a pH value of 8.4 during the August season. This pH value matched well with the 80th percentile pH for the data set from the USGS Sherwood station on the Souris River. The June and March runs performed by the SBDA model used pH values of 8.0 and 7.5, respectively. (It should be noted that EPA is modeling conditions representative of infrequent conditions to reflect compliance with the EPA national guidance for frequency requirements. This is different from the NEPA provision for "worst case" analyses which were rescinded by CEQ in 1986.)

EPA modeling of the range of possible dissolved oxygen and un-ionized ammonia values for the Souris River was compared to the modeling results from SBDA. EPA Regional analysis of water quality modeling for the Souris Basin Project during August indicated that the U.S./Canadian border concentrations of un-ionized ammonia could be as high as 0.3 mg/l-N for a single outlet and .15 mg/l-N for multiple outlets at both reservoirs. The North Dakota standard is not to exceed .02 mg/l-N. (See "Technical Review of Document: Proposed Rafferty and Alameda Reservoirs; Souris River Water Quality at Saskatchewan/North Dakota Boundary", March 25, 1988, Bruce Zander, Water Quality Requirements Section, EPA Region VIII, page 2.) The June modeled runs also predict exceedance of the state un-ionized ammonia standard, whereas the March runs show little problems. EPA concurred with the results of SBDA's dissolved oxygen modeling. The EPA modeling for un-ionized ammonia, however, warns of water quality standard exceedances at the border for "worst case" conditions which may have detrimental impacts on the regionally important fishery in Lake Darling. Model runs based upon the use of multiple level outlets for both proposed reservoirs to avoid hypolimitic release improved the ammonia release conditions substantially, but "worst case" modeled conditions at the border for either low outlet or mixed outlet releases at both reservoirs are predicted to exceed state standards both for low flow and high flow events.

The Corps has received the opinion of the North Dakota Department of Health that the proposed action is likely to cause the exceedance of state water quality standards. (See letter from the North Dakota Department of Health to the St. Paul District, September 1, 1988.) Recent correspondence from the Health Department to EPA Region VIII indicates the possibility of changing the un-ionized ammonia standard to reflect recent aquatic studies which show greater tolerance by aquatic species. The current standard for un-ionized ammonia of .02 mg/l-N could be changed to .10 mg/l-N pending scientific analysis by EPA and public review. (It is important to note that if the higher concentration were in effect, the results based upon the EPA modeling effort also indicate exceedances for this proposed higher concentration.) North Dakota and EPA will notify the Corps of any change in state water quality standards for the upcoming work on the supplemental information document.

Additional analysis of means to provide compliance with state water quality standards is needed. There is limited field data from the Souris River to verify the modeled conditions; thus we are uncertain of the degree of the predicted adverse consequences. Additional analyses may include obtaining the needed in-stream data to verify the modeled predictions, variations of the outlet design and release procedures, or

variations in the timing of flow releases. The proposed international monitoring committee to oversee operations will be an essential component to advise on the means and methods to avoid water quality problems. The proposed operational plan should include the method to assure that the water quality delivered across the border from the proposed project is able to meet state standards and not harm the beneficial uses of the Souris River in North Dakota.

Funding and institutional responsibilities must be completed for the proposed water quality monitoring network. Instituting the proposed bi-lateral water quality review board will be essential to identify and determine the means to correct possible water quality impacts after project operations. Prior to the Corps' proposed action, there need to be assurances that operational changes will be made to maintain compliance with applicable water quality standards. We suggest that the City of Minot obtain assurances that the mixing and timing of outlet operations will be with the City's concurrence. EPA, the North Dakota Department of Health, and the USFWS will provide technical assistance in this regard.

NEPA Compliance

The final EIS only partially addresses the question whether the predicted environmental impacts are independent actions by Canada or a result of U.S. assistance to the project and thus should be avoided or mitigated by U.S. action. After release of the draft EIS, the Province of Saskatchewan conditioned its approval of the Alameda/Rafferty project to construction of the Rafferty Dam at a smaller size unless the U.S. pays $41.1 million for flood control (Ministerial Approval Under the Environmental Assessment Act, Province of Saskatchewan, Department of Environment and Public Safety, H.J. Swan, February 15, 1988, page 10). The Corps needs to provide additional explanation to substantiate that the project proponents would proceed without the U.S. Government's participation.

The Corps is responsible under NEPA to disclose the cumulative impacts of the entire project regardless of who undertakes the action (40 CFR 1502.14(c) and 1508.7). The Corps is therefore obligated to consider whether the result of the project creates an adverse impact to fish and wildlife values and whether mitigation measures are warranted. Preparation of a supplemental information document, as suggested by EPA, could be used by the Corps to supplement the record, display information available on the impacts and measures to mitigate Canadian low flow operations, and to provide public review of the final versions of the proposed mitigation measures.

APPENDIX 5

THE BOUNDARY WATERS TREATY 1909

1909

[1]TREATY BETWEEN HIS MAJESTY AND THE UNITED STATES OF AMERICA RELATING TO BOUNDARY WATERS AND QUESTIONS ARISING ALONG THE BOUNDARY BETWEEN CANADA AND THE UNITED STATES.

Signed at Washington, January 11, 1909

[*Ratifications exchanged at Washington, May* 5, 1910]

His Majesty the King of the United Kingdom of Great Britain and Ireland and of the British Dominions beyond the Seas, Emperor of India, and the United States of America, being equally desirous to prevent disputes regarding the use of boundary waters and to settle all questions which are now pending between the United States and the Dominion of Canada involving the rights, obligations, or interests of either in relation to the other or to the inhabitants of the other, along their common frontier, and to make provision for the adjustment and settlement of all such questions as may hereafter arise, have resolved to conclude a Treaty in furtherance of these ends, and for that purpose have appointed as their respective Plenipotentiaries.

His Britannic Majesty, the Right Honourable James Bryce, O.M., his Ambassador Extraordinary and Plenipotentiary at Washington; and

The President of the United States of America, Elihu Root, Secretary of State of the United States;

[1] From Treaty Series No. 23, 1910.

Who, after having communicated to one another their full powers, found in good and due form, have agreed upon the following articles:

PRELIMINARY ARTICLE

For the purposes of this Treaty boundary waters are defined as the waters from main shore to main shore of the lakes and rivers and connecting waterways, or the portions thereof, along which the international boundary between the United States and the Dominion of Canada passes, including all bays, arms, and inlets thereof, but not including tributary waters which in their natural channels would flow into such lakes, rivers, and waterways, or waters flowing from such lakes, rivers, and waterways, or the waters of rivers flowing across the boundary.

ARTICLE 1

The High Contracting Parties agree that the navigation of all navigable boundary waters shall for ever continue free and open for the purposes of commerce to the inhabitants and to the ships, vessels, and boats of both countries equally, subject, however, to any laws and regulations of either country, within its own territory, not inconsistent with such privilege of free navigation, and applying equally and without discrimination to the inhabitants, ships, vessels, and boats of both countries.

It is further agreed that so long as this Treaty shall remain in force, this same right of navigation shall extend to the waters of Lake Michigan and to all canals connecting boundary waters, and now existing or which may hereafter be constructed on either side of the line. Either of the High Contracting Parties may adopt rules and regulations governing the use of such canals within its own territory, and may charge tolls for the use thereof, but all such rules and regulations and all tolls charged shall apply alike to the subjects or citizens of the High Contracting Parties and the ships, vessels, and boats of both of the High Contracting Parties, and they shall be placed on terms of equality in the use thereof.

ARTICLE 2

Each of the High Contracting Parties reserves to itself or to the several State Governments on the one side and the Dominion or Provincial Governments on the other, as the case may be, subject to any treaty provisions now existing with respect thereto, the exclusive jurisdiction and control over the use and diversion, whether temporary or permanent, of all waters on its own side of the line which in their natural channels would flow across the boundary or into boundary waters; but it is agreed that any interference with or diversion from their natural channel of such waters on either side of the boundary, resulting in any injury on the other side of the boundary, shall give rise to the same rights and entitle the injured parties to the same legal remedies as if such injury took place in the country where such diversion or interference occurs; but this provision shall not apply to cases already existing or to cases expressly covered by special agreement between the parties hereto.

It is understood, however, that neither of the High Contracting Parties intends by the foregoing provision to surrender any right which it may have to object to any interference with or diversions of waters on the other side of the boundary the effect of which would be productive of material injury to the navigation interests on its own side of the boundary.

ARTICLE 3

It is agreed that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special agreement between the Parties

hereto, no further or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, affecting the natural level or flow of boundary waters on the other side of the line, shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission.

The foregoing provisions are not intended to limit or interfere with the existing rights of the Government of the United States on the one side and the Government of the Dominion of Canada on the other, to undertake and carry on governmental works in boundary waters for the deepening of channels, the construction of breakwaters, the improvement of harbours, and other governmental works for the benefit of commerce and navigation, provided that such works are wholly on its own side of the line and do not materially affect the level or flow of the boundary waters on the other, nor are such provisions intended to interfere with the ordinary use of such waters for domestic and sanitary purposes.

ARTICLE 4

The High Contracting Parties agree that, except in cases provided for by special agreement between them, they will not permit the construction or maintenance on their respective sides of the boundary of any remedial or protective works or any dams or other obstructions in waters flowing from boundary waters or in waters at a lower level than the boundary in rivers flowing across the boundary, the effect of which is to raise the natural level of waters on the other side of the boundary unless the construction or maintenance thereof is approved by the aforesaid International Joint Commission.

It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other.

ARTICLE 5

The High Contracting Parties agree that it is expedient to limit the diversion of waters from the Niagara River so that the level of Lake Erie and the flow of the stream shall not be appreciably affected. It is the desire of both Parties to accomplish this object with the least possible injury to investments which have already been made in the construction of power plants on the United States' side of the river under grants of authority from the State of New York, and on the Canadian side of the river under licenses authorized by the Dominion of Canada and the Province of Ontario.

So long as this Treaty shall remain in force, no diversion of the waters of the Niagara River above the Falls from the natural course and stream thereof shall be permitted except for the purposes and to the extent hereinafter provided.

The United States may authorise and permit the diversion within the State of New York of the waters of said river above the Falls of Niagara, for power purposes, not exceeding in the aggregate a daily diversion at the rate of twenty thousand cubic feet of water per second.

The United Kingdom, by the Dominion of Canada, or the Province of Ontario, may authorise and permit the diversion within the Province of Ontario of the waters of said river above the Falls of Niagara for power purposes, not exceeding in the aggregate a daily diversion at the rate of thirty-six thousand cubic feet of water per second.

The prohibitions of this article shall not apply to the diversion of water for sanitary or domestic purposes, or for the service of canals for the purposes of navigation.

ARTICLE 6

The High Contracting Parties agree that the St. Mary and Milk Rivers and their tributaries (in the State of Montana and the Provinces of Alberta and Saskatchewan) are to be treated as one stream for the purposes of irrigation and power, and the waters thereof shall be apportioned equally between the two countries, but in making such equal apportionment more than half may be taken from one river and less than half from the other by either country so as to afford a more beneficial use to each. It is further agreed that in the division of such waters during the irrigation season, between the 1st of April and 31st of October inclusive, annually, the United States is entitled to a prior appropriation of 500 cubic feet per second of the waters of the Milk River, or so much of such amount as constitutes three-fourths of its natural flow, and that Canada is entitled to a prior appropriation of 500 cubic feet per second of the flow of St. Mary River, or so much of such amount as constitutes three-fourths of its natural flow.

The channel of the Milk River in Canada may be used at the convenience of the United States for the conveyance, while passing through Canadian territory, of waters diverted from the St. Mary River. The provisions of Article 2 of this Treaty shall apply to any injury resulting to property in Canada from the conveyance of such waters through the Milk River.

The measurement and apportionment of the water to be used by each country shall from time to time be made jointly by the properly-constituted reclamation officers of the United States and the properly-constituted irrigation officers of His Majesty under the direction of the International Joint Commission.

ARTICLE 7

The High Contracting Parties agree to establish and maintain an International Joint Commission of the United States and Canada composed of six commissioners, three on the part of the United States appointed by the President thereof, and three on the part of the United Kingdom appointed by His Majesty on the recommendation of the Governor in Council of the Dominion of Canada.

ARTICLE 8

This International Joint Commission shall have jurisdiction over and shall pass upon all cases involving the use or obstruction or diversion of the waters with respect to which under Articles 3 and 4 of this Treaty the approval of this Commission is required, and in passing upon such cases the Commission shall be governed by the following rules and principles which are adopted by the High Contracting Parties for this purpose:

The High Contracting Parties shall have, each on its own side of the boundary, equal and similar rights in the use of the waters hereinbefore defined as boundary waters.

The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence:

(1) Uses for domestic and sanitary purposes;
(2) Uses for navigation, including the service of canals for the purposes of navigation;
(3) Uses for power and for irrigation purposes.

The foregoing provisions shall not apply to or disturb any existing uses of boundary waters on either side of the boundary.

The requirement for an equal division may in the discretion of the Commission be suspended in cases of temporary diversions along boundary waters at points where such equal division can not be made advantageously on account of local conditions, and where such diversion does not diminish elsewhere the amount available for use on the other side.

The Commission in its discretion may make its approval in any case conditional upon the construction of remedial or protective works to compensate so far as possible for the particular use or diversion proposed, and in such cases may require that suitable and adequate provision, approved by the Commission, be made for the protection and indemnity against injury of any interests on either side of the boundary.

In cases involving the elevation of the natural level of waters on either side of the line as a result of the construction or maintenance on the other side of remedial or protective works or dams or other obstructions in boundary waters or in waters flowing therefrom or in waters below the boundary in rivers flowing across the boundary, the Commission shall require, as a condition of its approval thereof, that suitable and adequate provision, approved by it, be made for the protection and indemnity of all interests on the other side of the line which may be injured thereby.

The majority of the Commissioners shall have power to render a decision. In case the Commission is evenly divided upon any question or matter presented to it for decision, separate reports shall be made by the Commissioners on each side to their own Government. The High Contracting Parties shall thereupon endeavour to agree upon an adjustment of the question or matter of difference, and if an agreement is reached between them, it shall be reduced to writing in the form of a protocol, and shall be communicated to the Commissioners, who shall take such further proceedings as may be necessary to carry out such agreement.

ARTICLE 9

The High Contracting Parties further agree that any other questions or matters of difference arising between them involving the rights, obligations, or interests of either in relation to the other or to the inhabitants of the other, along the common frontier between the United States and the Dominion of Canada, shall be referred from time to time to the International Joint Commission for examination and report, whenever either the Government of the United States or the Government of the Dominion of Canada shall request that such questions or matters of difference be so referred.

The International Joint Commission is authorized in each case so referred to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

Such reports of the Commission shall not be regarded as decisions of the questions or matters so submitted either on the facts or the law, and shall in no way have the character of an arbitral award.

The Commission shall make a joint report to both Governments in all cases in which all or a majority of the Commissioners agree, and in case of disagreement the minority may make a joint report to both Governments, or separate reports to their respective Governments.

In case the Commission is evenly divided upon any question or matter referred to it for report, separate reports shall be made by the Commissioners on each side to their own Government.

ARTICLE 10

Any questions or matters of difference arising between the High Contracting Parties involving the rights, obligations, or interests of the United States or of the Dominion of Canada either in relation to each other or to their respective inhabitants, may be referred for decision to the International Joint Commission by the consent of the two Parties, it being understood that on the part of the United States any such action will be by and with the advice and consent of the Senate, and on the part of His Majesty's Government with the consent of the Governor General in Council. In each case so referred, the said Commission is authorized to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

A majority of the said Commission shall have power to render a decision or finding upon any of the questions or matters so referred.

If the said Commission is equally divided or otherwise unable to render a decision or finding as to any questions or matters so referred, it shall be the duty of the Commissioners to make a joint report to both Governments, or separate reports to their respective Governments, showing the different conclusions arrived at with regard to the matters or questions so referred, which questions or matters shall thereupon be referred for decision by the High Contracting Parties to an umpire chosen in accordance with the procedure prescribed in the fourth, fifth, and sixth paragraphs of Article XLV of The Hague Convention for the pacific settlement of international disputes, dated October 18, 1907. Such umpire shall have power to render a final decision with respect to those matters and questions so referred on which the Commission failed to agree.

ARTICLE 11

A duplicate original of all decisions rendered and joint reports made by the Commission shall be transmitted to and filed with the Secretary of State of the United States and the Governor General of the Dominion of Canada, and to them shall be addressed all communications of the Commission.

ARTICLE 12

The International Joint Commission shall meet and organize at Washington promptly after the members thereof are appointed, and when organized the Commission may fix such times and places for its meetings as may be necessary, subject at all times to special call or direction by the two Governments. Each Commissioner, upon the first joint meeting of the Commission after his appointment, shall, before proceeding with the work of the Commission, make and subscribe a solemn declaration in writing that he will faithfully and impartially perform the duties imposed upon him under this Treaty, and such declaration shall be entered on the records of the proceedings of the Commission.

The United States and Canadian sections of the Commission may each appoint a secretary, and these shall act as joint secretaries of the Commission at its joint sessions, and the Commission may employ engineers and clerical assistants from time to time as it may deem advisable. The salaries and personal expenses of the Commission and of the secretaries shall be paid by their respective Governments, and all reasonable and necessary joint expenses of the Commission, incurred by it, shall be paid in equal moieties by the High Contracting Parties.

The Commission shall have power to administer oaths to witnesses, and to take evidence on oath whenever deemed necessary in any proceeding, or inquiry, or matter within its jurisdiction under this Treaty, and all parties interested therein shall be given convenient opportunity to be heard, and the High Contracting Parties agree to adopt such legislation as may be appropriate and necessary to give the Commission the powers above mentioned on each side of the boundary, and to provide for the issue of subpœnas and for compelling the attendance of witnesses in proceedings before the Commission. The Commission may adopt such rules of procedure as shall be in accordance with justice and equity, and may make such examination in person and through agents or employees as may be deemed advisable.

ARTICLE 13

In all cases where special agreements between the High Contracting Parties hereto are referred to in the forgoing articles, such agreements are understoood and intended to include not only direct agreements between the High Contracting Parties, but also any mutual arrangement between the United States and the Dominion of Canada expressed by concurrent or reciprocal legislation on the part of Congress and the Parliament of the Dominion.

ARTICLE 14

The present Treaty shall be ratified by His Britannic Majesty and by the President of the United States of America, by and with the advice and consent of the Senate thereof. The ratifications shall be exchanged at Washington as soon as possible, and the Treaty shall take effect on the date of the exchange of its ratifications. It shall remain in force for five years, dating from the day of exchange of ratifications, and thereafter until terminated by twelve months' written notice given by either High Contracting Party to the other.

In faith whereof the respective plenipotentiaries have signed this Treaty in duplicate and have hereunto affixed their seals.

Done at Washington the 11th day of January, in the year of our Lord one thousand nine hundred and nine.

[L.S.] JAMES BRYCE.
[L.S.] ELIHU ROOT.

PROTOCOL OF EXCHANGE[1]

On proceeding to the exchange of the ratifications of the treaty signed at Washington on January 11, 1909, between Great Britain and the United States, relating to boundary waters and questions arising along the boundary between the United States and the Dominion of Canada, the undersigned plenipotentiaries, duly authorized thereto by their respective Governments, hereby declare that nothing in this treaty shall be construed as affecting, or changing, any existing territorial, or riparian rights in the water, or rights of the owners of lands under water, on either side of the international boundary at the rapids of the St. Mary's River at Sault Ste. Marie, in the use of the waters flowing over such lands, subject to the requirements of navigation in boundary waters and of navigation canals, and without prejudice to the existing right of the United States and Canada, each to use the waters of the St. Mary's River, within its own territory; and further, that nothing in this treaty shall be construed to interfere with the drainage of wet, swamp, and overflowed lands into streams

[1] The British Ratification of this further Instrument was deposited with the United States Government on July 28, 1910.

APPENDIX 6

INTERNATIONAL JOINT COMMISSION 1959 INTERIM MEASURES

(SOURIS RIVER APPORTIONMENT)

1959 INTERIM MEASURES

(Extract from IJC Docket #41)

The Commission recommends that it be authorized to create the Board referred to in paragraph 21 above and that the two Governments approve the following interim measures in substitution for the interim measures which were recommended in the report dated 2 October 1940 and heretofore approved:

1. The Province of Saskatchewan shall have the right to divert, store, and use waters which originate in the Saskatchewan portion of the Souris River basin, provided that such diversion, storage and use shall not diminish the annual flow of the river at the Sherwood Crossing more than fifty percent of that which would have occurred in a state of nature. For the benefit of riparian users of water between the Sherwood Crossing and the upstream end of Lake Darling, the Province of Saskatchewan shall so far as practicable regulate its diversions, storage, and uses in such manner that the flow in the Souris River channel at the Sherwood Crossing shall not be less than four (4) cubic feet per second when that much flow would have occurred under the conditions of water use development prevailing in the Saskatchewan portion of the Souris River basin prior to construction of the Long Creek dam referred to in paragraphs 12 and 14 above.

2. Except as otherwise provided herein with respect to delivery of water to the Province of Manitoba, the State of North Dakota shall have the right to divert, store, and use the waters which originate in the North Dakota portion of the Souris River basin together with the waters delivered to the State of North Dakota at the Sherwood Crossing under Recommendation (1) above; provided, that any diversion, use or storage of Long Creek water shall not diminish the annual flow at the eastern crossing of Long Creek into Saskatchewan below the annual flow of said Creek at the western crossing into North Dakota.

3. (a) In addition to the waters of the Souris River basin which originate in the Province of Manitoba, that Province shall have the right, except during periods of severe drought, to receive for its own use and the State of North Dakota shall deliver from any available source during the months of June, July, August, September, and October of each year, six thousand and sixty-nine (6,069) acre-feet of water at the Westhope Crossing regulated so far as practicable at the rate of twenty (20) cubic feet per second except as set forth hereinafter: provided, that in delivering such water to Manitoba no account shall be taken of water crossing the boundary at a rate in excess of the said 20 cubic feet per second.

3. (b) In periods of severe drought when it becomes impracticable for the State of North Dakota to provide the foregoing regulated flows, the responsibility of the State of North Dakota in this connection shall be limited to the provision of such flows as may be practicable, in the opinion of the said Board of Control, in accordance with the objective of making water available for human and livestock consumption and for household use. It is understood that in the circumstances contemplated in this paragraph the State of North Dakota will give the earliest possible advice to the International Souris River Board of Control with respect to the onset of severe drought conditions.

4. In event of disagreement between the two sections of the International Souris Board of Control, the matters in controversy shall be referred to the Commission for decision.

5. The interim measures for which provision is herein made shall remain in effect until the adoption of permanent measures in accordance with the requirements of questions (1) and (2) of the Reference of 15 January, 1940, unless before that time, these interim measures are qualified or modified by the Commission.

APPENDIX 7

MANITOBA DEPARTMENT OF NATURAL RESOURCES

WATER QUANTITY ANALYSIS

PS-1-25

Manitoba

Memorandum

Date November 23, 1987

To V. M. Austford, P. Eng.
Chief of Hydrotechnical Services

From R. J. Bowering, P. Eng.
Head, Hydrology Section

File: 96.9.8

Subject IMPACT OF OPERATION OF RAFFERTY AND ALAMEDA DAMS ON MANITOBA

Telephone 6397

First | Fold

Introduction

The Saskatchewan Water Corporation has proposed the construction of two major reservoirs in the Souris River basin in southeastern Saskatchewan. The two dams are shown on Figure 1. The Rafferty Dam would be located on the Souris River west of Estevan and the Alameda Dam would be located on Moose Mountain Creek near its confluence with the Souris River. Saskatchewan is proposing these reservoirs to augment water supply.

North Dakota's interest in this project is related to flood control at Minot, North Dakota. Previously the Corps of Engineers had considered constructing a dam near Burlington, North Dakota or raising Lake Darling. I was the Manitoba member on two Burlington Dam Task Forces and on the Lake Darling Task Force. These Task Forces reviewed proposed operating plans and examined the impact flow changes would have on Manitoba. The 1984 Task Force report found that Lake Darling operation would have a variable impact on flooding in Manitoba.

Because of considerable local opposition to both the Burlington and Lake Darling projects, and because of the high costs involved, no further action was taken. However, the proposed Rafferty and Alameda Dams in Saskatchewan are very attractive to North Dakota. They have sufficient capacity to prevent flooding at Minot from up to a 100 year flood and they involve no land disruption in the state.

In July of 1987 the Souris Basin Development Authority released an Environmental Impact Statement. However, this study was limited to impacts in Saskatchewan only.

We have been in regular contact over the past couple of years with officials from the North Dakota State Water Commission and the St. Paul District of the U.S. Army Corps of Engineers. They have provided us with drafts of the proposed operating plan and with streamflow simulations. This report contains an analysis of these flow files and an assessment of water quantity impacts which would accrue to Manitoba if the project proceeds.

Impacts on flood flows will be discussed first then the overall flow regime will be discussed.

Flood Flows

The St. Paul District of the U.S. Army Corps of Engineers simulated project operation for five high flow years on the Souris River; 1969, 1974, 1975, 1976, and 1979. In addition, two approximations of the 100 year flood were also generated. Simulations were done using the HEC-5 flow routing model.

These flow files were extended into Manitoba by the Water Resources Branch using the Muskingum Flood Routing Model. Flows were developed for seven river reaches between Westhope and Wawanesa.

The method of analysis was the same as that used by the Lake Darling Task Force. In that study Manitoba Water Resources used the Agricultural Damage Model developed for the Souris River Basin Study to estimate agricultural damages in Manitoba. The urban damage curves from the Souris River Basin Study for Melita, Souris and Wawanesa were updated to 1982 dollars.

During the Task Force Study it was argued that modified flows should not be compared to recorded flows because the U.S. Fish and Wildlife Service have changed their operating procedures for Lake Darling over the years. Therefore, the existing operation was simulated for each of the study years and these flows were routed to Westhope and then to Wawanesa. Damages were computed for these flows and formed the basis for comparison.

The economic damages arising from the Rafferty/Alameda operation have been computed in exactly the same manner used by the Lake Darling Task Force. Results are given in 1982 dollars so that they will be directly comparable.

Hydrographs of the simulated existing and post project flows for seven Manitoba locations are included in Attachment A for the flood years and for the two "100 Year" hydrographs. In the plots the solid lines represent simulated existing flows and the dashed lines are for post project flows.

Agricultural Damages

Agricultural damages were computed for five flood reaches on the Souris River between Westhope and Hartney for the five high flow years. The flood reaches are shown on Figure 2. Each flood reach was divided into three elevation bands; lower, middle, and upper. This was done so that the impact of project operation can be shown at a variety of locations.

The analysis results are given in Tables 1 to 5. For comparison the results of the Lake Darling simulations are also included. These tables indicate that for most cases Rafferty/Alameda operation would reduce agricultural flood damages in Manitoba. The hydrographs in Attachment A show that under post project operation flood waters recede much more quickly because of storage of flood runoff in the Saskatchewan reservoirs.

There are, however, a couple of occurrences of increased agricultural damage even though the hydrographs show a faster recession of

the flows. A good example is the 1969 hydrograph for Peninsula Bridge. The reason for the increased damage is that the early May recession would permit the farmer to plant his crop by mid-May. However the hydrograph shows a second major peak arriving in late May which would inundate his field. His seed and planting costs would be lost, thereby causing him greater damage than under the existing condition where he would not have been able to get on the land.

Although this delayed second peak is the most obvious in the 1969 simulation, there is evidence of it in each of the flood years. For example an examination of the routings for 1976 indicates that discharges from Rafferty would be held to zero until April 20 in 1976, and would rise to a peak of 2546 cfs by April 22. Similarly Alameda outflows would not start until April 25 and then would average around 1000 cfs for a week or so. These flows reach Sherwood on about April 25, peaking on about May 1. The slug of water would reach Minot on May 10 and Westhope on about May 21. Therefore this mid to late May surge which is evident in each of the flood years apparently results from the opening of the Rafferty and Alameda outlets. Even though the flows remain below the levels which would occur under existing operation, they could cause additional damage as a result of reflooding dried and potentially cultivated land.

With proper forecast disemination procedures this damage resulting from reflooding may in fact be preventable. As the waters initially receed our runoff forecasts would indicate that the second peak would be following. This information could be relayed to the farmers so that they would not plant their crop before the second peak has passed.

Urban Damages

Table 6 shows peak flows, river levels and damages in 1982 dollars for both existing and post project conditions for Melita, Souris and Wawanesa for the five high flow years.

Melita experienced flooding in each of the five flood years. Table 6 indicates that the damage would be unchanged in one year, less in three years, and greater in the one other year. Over the 52 year period from 1936 to 1987 the average annual decrease in damage would be $667.

Souris and Wawanesa only suffered significant flood damages in 1976. The routings indicate that operation of the project would have decreased peak levels in both communities by a small amount, resulting in damages reductions of $13,800 and $13,100 respectively. The Lake Darling Task Force and earlier Rafferty simulations found that reservoir operation would have increased damages in these two communities in 1976. The increased peak levels arose from the practice of starting reservoir releases before runoff commences. In 1976 these seemingly minor increases in outflow would have tended to arrive in Manitoba just as the runoff was peaking in the local tributaries. In years like 1976 this local runoff peak is larger than the secondary peak which is caused by runoff upstream from Minot. Therefore, for Souris and Wawanesa, the early releases of the reservoirs tended to increase flood damage. In the latest simulations, these early flows were held in Lake Darling, allowing it to rise towards its summer level. This change in operation of Lake Darling is of significant benefit to Manitoba.

High Flow Simulation Results

Table 7 summarizes the flood damage simulation results for Manitoba for the five flood years. Net benefits are computed benefits minus computed damages. Gross damages show the differences between damages arising from post project operation and from existing operation, except that all benefits are considered to be a "windfall" and are ignored.

Table 7 indicates that project operation would give an average annual net benefit to agriculture of $7500 and an average annual net urban benefit of $1200. The average annual gross damages would be $110 for agriculture and $4800 for urban.

Figures 3 and 4 summarize the agricultural and urban damages under historic and full project operation for each flood event studied.

Hundred Year Flood Simulation

Because of the requirement of providing flood protection to the 100 year flood level at Minot, the Corps also simulated existing and post project hydrographs for two approximations of the hundred year flood. The first approximation multiplied all 1976 flows by 1.5. The second multiplied all 1979 flows by 2.0. These two events were selected because the 1976 hydrograph represents a flood event which occurred early in the spring and the 1979 event represents a later flood.

These hydrographs were routed through Manitoba multiplying the local inflows by the same factors. This, of course, should make the events simulated for Manitoba rarer than the 100 year flood, but they did provide some very interesting results.

The hydrographs for both simulations are included in attachment A. Again the solid line represents existing operation and the dashed line represents post project operation.

Table 8 summarizes the agricultural damages for existing and post project flows for both simulations. In both cases project operation would reduce average flood damages in Manitoba. The damages would be reduced by $14,700 (one percent) for the first simulation and by $254,200 (20 percent) for the second simulation. A couple of flood bands show small damage increases for the first simulation, but all flood bands show reduced damages for the second simulation.

Table 9 lists the urban damages which would result for each of the 100 year flood simulations. For all three locations both simulations showed reduced urban damages under post project operation. The damage for the first simulation would be reduced by $472,300 (18 percent) and for the second simulation by $257,700 (67 percent).

It is significant that these two decidedly different 100 year floods both result in reduced agricultural and urban damages in Manitoba. The reason is that the main flood peak in Manitoba is not caused by local runoff during these very large events. Therefore, the peak flow reductions for Minot transfer to Manitoba.

The difference in impact on urban flooding is also informative.

For the flood based on 1976 flows, the post project simulation produced flows at the 5000 cfs channel capacity through Minot two weeks before local runoff commenced in Manitoba, therefore, the local runoff downstream from Minot all added to this 5000 cfs. For the second simulation based on 1979 data, local runoff was completed by the time flows at Minot reached 5000 cfs. Therefore, the hydrographs in Manitoba are much flatter for post project operation, resulting in much less urban damage. However agricultural damage is similar for both simulations because the runoff based on augmented 1979 flows occures later in the spring, thereby delaying cropping.

Normal Flow Regime

The preceding analyses concentrated on changes in runoff patterns during flood events. Daily flow arrays were required to examine changes in runoff patterns. However, to look at overall changes in the flow regime it is normal to examine simulated monthly flows for an extended period of record.

Saskatchewan and the North Dakota State Water Commission simulated monthly flows under project operation for the 63 year period from 1912 to 1974. This period was assumed to represent a typical range of flows occurring in the Souris River. Saskatchewan developed these simulations to determine how much water could be made available for water supply in Saskatchewan. North Dakota required the data to assess the impact on flows in the Souris River in North Dakota.

Two flow files were simulated to demonstrate the flow regime under full project operation. Under the Interim Measures Agreement, Saskatchewan is required to pass to North Dakota at least 50 percent of the flows arising in the Souris River Basin in Saskatchewan. The first simulation adhered to this 50/50 sharing formula.

Once the new reservoirs are filled a considerable volume of water will be lost each year through evaporation from the reservoir surfaces. Saskatchewan and North Dakota have tentatively agreed to share this water loss through a modified formula for sharing of flows at their border. They have agreed to maintain the 50/50 formula in dry years, but in normal and wet years, Saskatchewan would only have to pass 40 percent of the natural flow, the other 10 percent being attributed to evaporation loss. There is some question as to whether this change would violate the Interim Measures. However, the second simulation was produced using this modified formula to determine its impact on flows.

Copies of the two files for the North Dakota/Manitoba border were received from the North Dakota State Water Commission. Tables 10 and 11 list the flows for these two simulations. The two files are very similar, only differing at higher flows. Table 12 lists recorded flows at the International Boundary for 1931 to 1986.

Figure 5 summarizes changes in the long-term average flow for each month under the two apportionment formulas. The overall average flow would be reduced by 18.7 percent under the 50/50 formula and by 18.9 percent under the 40/60 formula.

Attachment B contains duration curves for the months of April to June, July to September and October to March for the historic flows and

for the two flow simulations. To ensure compatability between the simluated and recorded flows, only flows simulated for the period 1931 to 1974 were used in the analysis. Duration curves show the percent of time the flows are less than or equal to a given value. For example, the curves for the April to June quarter show that historically flows in the Souris River at Westhope exceeded 200 cfs 50 percent of the time. Under both apportionment proposals, a flow of 200 cfs would be exceeded 40 percent of the time. The curve for the July to September quarter indicates that historically 200 cfs was exceeded 20 percent of the time. Under both apportionment formulas 200 cfs would be exceeded 27 percent of the time during the summer period.

I have only had general discussions with North Dakota officials about how these flow files were developed. I am not familiar with the simulation model they used, or the assumption inherent in it. Therefore, I do not have a good indication of how much confidence we can place in the results. I note that for 1933 to 1935 and for 1945 the simulated annual flow volumes at Westhope for both simulations are less than the difference between the recorded annual volumes at Westhope and Sherwood. This is not physically possible unless the model is assuming a considerably larger water usage in the North Dakota portion of the basin for those years than what was actually used. However, the rest of the results do look reasonable and are probably not too bad.

Reservoir Filling Period

None of the flow files received from the U.S. Army Corps of Engineers or from the North Dakota State Water Commission contain flow simulations for the reservoir filling phase. These reservoirs are large in comparison to the annual flow in the Souris River. The Saskatchewan Environmental Impact Statement stated that there is only a 50 percent chance that the Rafferty reservoir could be filled in 12 years. Therefore, if the reservoirs are constructed chances are that Saskatchewan will be holding back water for reservoir filling until the 21st Century.

Reservoir filling, of course, would not aggravate flooding, so there is no need to simulate the flood flows for the reservoir filling period. The impact would be felt in water supply. Flows in the Souris River during the reservoir filling period would be lower than the simulated flows given in Tables 10 and 11.

In order to assess a worst case scenario, a modified flow file was generated for the North Dakota/Manitoba border assuming that 60 percent of the historic flow at the Saskatchewan/North Dakota border would be held back for reservoir filling. The formula was only relaxed if this caused flows entering Manitoba to drop below the minimum of 20 cfs (0.566 cubic metres per second) specified in the Interim Measures. Assuming that we would not change that formula, the flow at the Manitoba border was set equal to the recorded flow whenever the modification would reduce Manitoba's share below 20 cfs.

The resulting flow file is shown in Table 13 and summarized on Figure 6. Appendix C contains duration curves for the months of April to June, July to September and October to March.

According to these results, the long-term average flow in the Souris River in Manitoba would be reduced by 29 percent from 261 cfs to

186 cfs during the reservoir filling phase. It is also interesting to note that the reduced flows would not eliminate flooding on the Souris River in Manitoba. For example, the April, 1976 average would be reduced from 8850 to 7278 cfs. The reservoir filling would not eliminate flooding because half of the flow entering Manitoba in the Souris River rises downstream of the two Saskatchewan reservoirs.

It should be stressed that these flow simulations represent a worst case scenario. Historic flows entering North Dakota from Saskatchewan have been reduced by 60 percent to represent the possibility that the proposed 60/40 apportionment formula may be approved. However, according to the tentative agreement between Saskatchewan and North Dakota, the formula would revert to 50/50 during dry years. Also the recorded flows already are reduced below the natural flows because of historic water use in Saskatchewan. Therefore, this simulation should take 40 percent of the higher natural flow rather than 40 percent of the historic flow. However, natural flow files for the Saskatchewan/North Dakota border were not readily available.

Changes to Operating Plan

All of the preceding analyses presume that Rafferty, Alameda and Lake Darling will be operated in strict accordance with the operating plan. However, in actual operation there may well be variances from the plan.

Saskatchewan's interest is water conservation. They are, therefore, not likely to draw down the reservoirs more than the operating plan suggests. If they do draw the reservoirs down less, they will have a smaller impact on flows. Therefore, flows in Manitoba should move closer to simulated existing flows.

The Corps of Engineers is assuming that late winter releases will be made to draw down the reservoirs if forecasts indicate a large runoff. These late winter releases may well be restricted because of ice build-up in the river channel. This would be advantageous to Manitoba because these late winter releases caused the simulated increase in 1976 flood peaks in Manitoba.

The latest simulations have reduced the rate of flow from Lake Darling at the start of runoff. This modification results in reduced damages in Manitoba.

It is, therefore, likely that minor variances in the project operation would not increase damages in Manitoba above those simulated in this study.

Conclusion

On average, Rafferty and Alameda operation provide considerably more flood-related benefits to Manitoba than damages. The agricultural damage increases which the Lake Darling Task Force simulated were largely caused by the U.S. Fish and Wildlife Service's desire to draw down Lake Darling at the end of each flood. With Rafferty and Alameda these volumes would be held in Saskatchewan, thereby causing a much faster flow recession in Manitoba. The benefits to Manitoba associated with the

relatively minor change in operation of Lake Darling are significant. Manitoba should endeavor to obtain assurances from the Corps of Engineers that the reservoir would be operated in this fashion once the project is in place.

The flow regime simulations indicate that average flows in the Souris River would be reduced by project operation, but that North Dakota would have sufficient river flows to continue to pass to Manitoba the flow volume stipulated in the Interim Measures. These flows would be sufficient to meet current water uses in Manitoba. In fact, according to the post project simulations, flows in the July to September period would be higher under full project operation.

During the reservoir filling phase flows would be reduced somewhat further. However, the overall average flow reduction would only be in the order of 10 percent below the average that would occur under full project operation. Sufficient flows would still be available to meet Manitoba's flow requirement as stipulated in the Interim Measures.

Finally, it must be recognized that there is considerable pressure in North Dakota to find a remedy for the persistent flooding problems at Minot. Of all of the Minot flood reduction schemes that have been examined in the past, the Rafferty/Alameda proposal provides the most water quantity related benefits and least damage to Manitoba.

R. J. Bowering

RJB/emb
Attachment

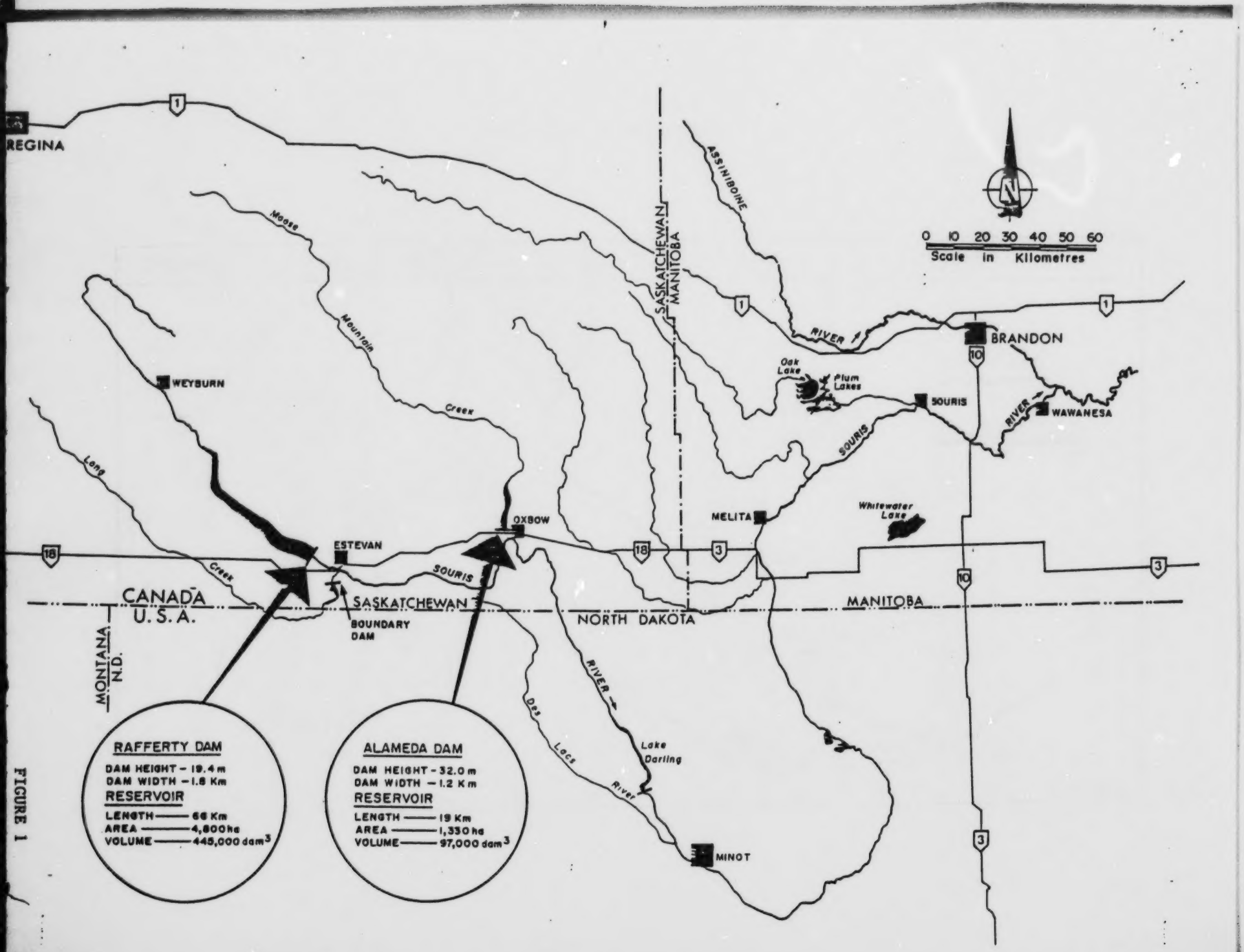

REGINA
1
SASKATCHEWAN
MANITOBA
ASSINIBOINE
RIVER
BRANDON
10
Oak Lake
Plum Lakes
SOURIS
RIVER
WAWANESA
SOURIS
Moose
Mountain
Creek
WEYBURN
Long
Creek
OXBOW
MELITA
Whitewater Lake
ESTEVAN
18
3
SOURIS
CANADA
U.S.A.
SASKATCHEWAN
MANITOBA
NORTH DAKOTA
BOUNDARY DAM
MONTANA
N.D.
RIVER
Des Lacs
River
Lake Darling
MINOT
0 10 20 30 40 50 60
Scale in Kilometres
RAFFERTY DAM
DAM HEIGHT - 19.4 m
DAM WIDTH - 1.8 Km
RESERVOIR
LENGTH — 66 Km
AREA — 4,800 ha
VOLUME — 445,000 dam3
ALAMEDA DAM
DAM HEIGHT - 32.0 m
DAM WIDTH - 1.2 Km
RESERVOIR
LENGTH — 19 Km
AREA — 1,330 ha
VOLUME — 97,000 dam3

FIGURE 1

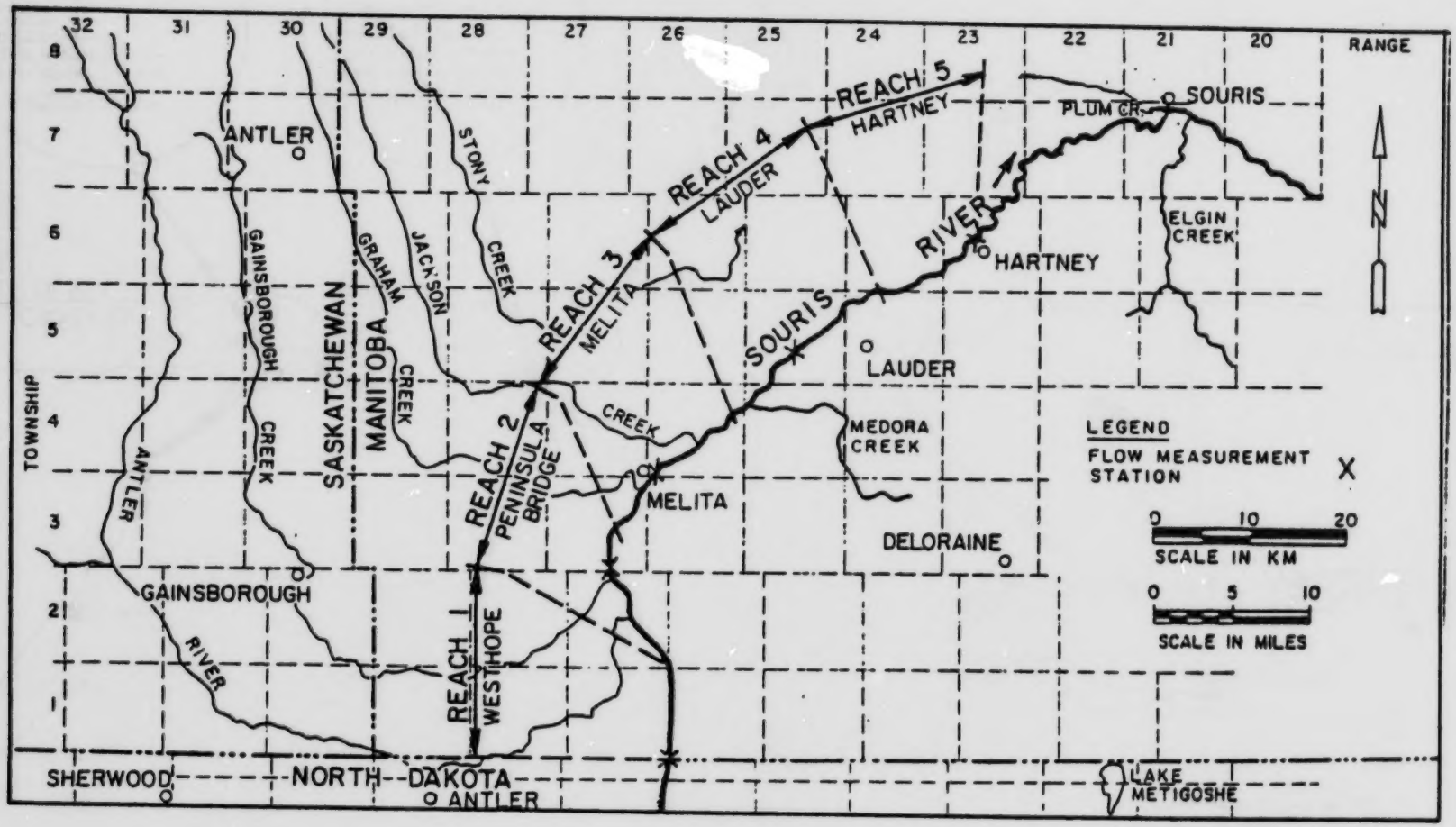


FIGURE 2

SOURIS RIVER FLOOD REACHES

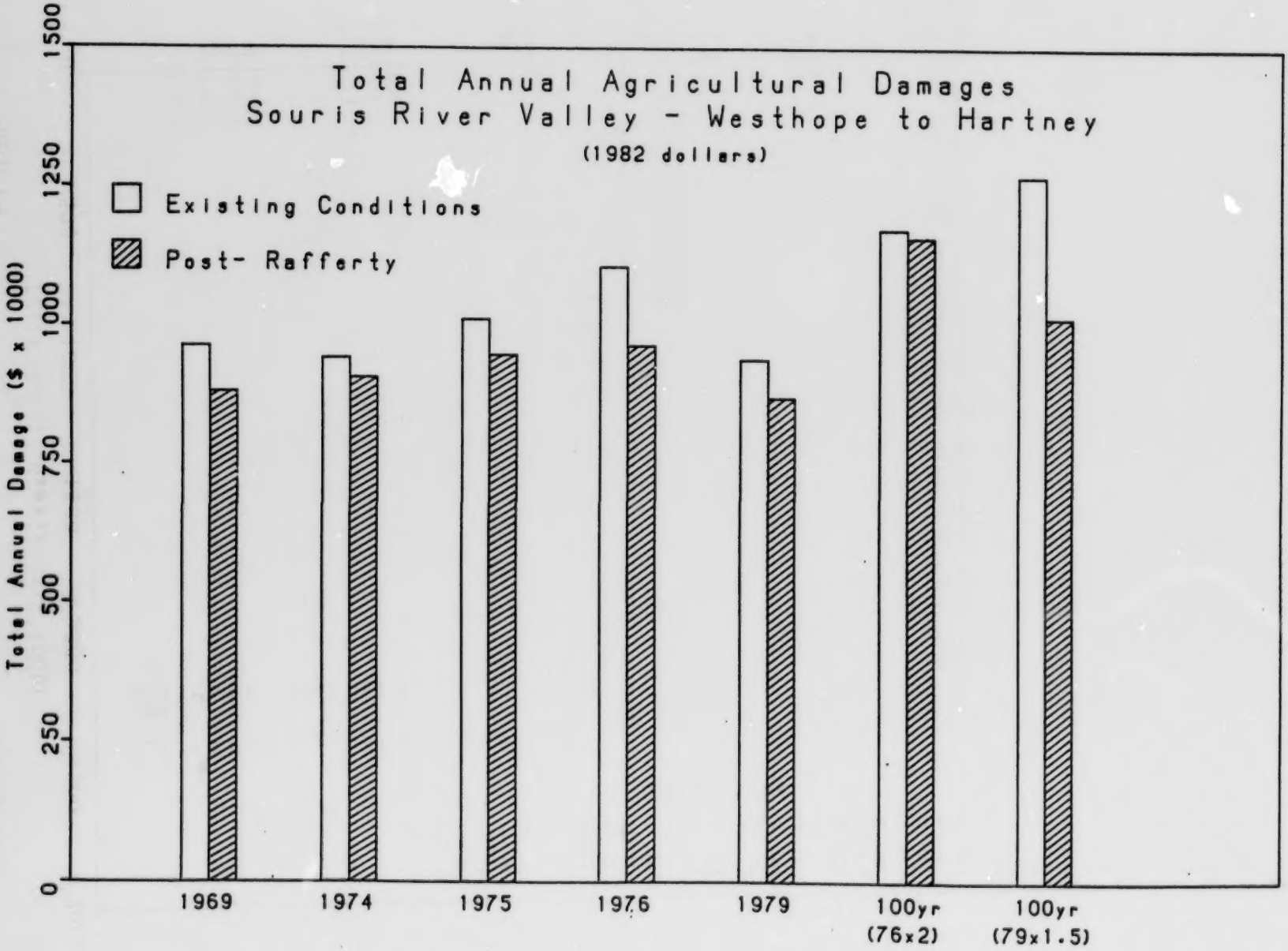

Total Annual Agricultural Damages
Souris River Valley - Westhope to Hartney
(1982 dollars)
Existing Conditions
Post- Rafferty
Total Annual Damage ($ x 1000)
0
250
500
750
1000
1250
1500
1969
1974
1975
1976
1979
100yr (76x2)
100yr (79x1.5)

FIGURE 3

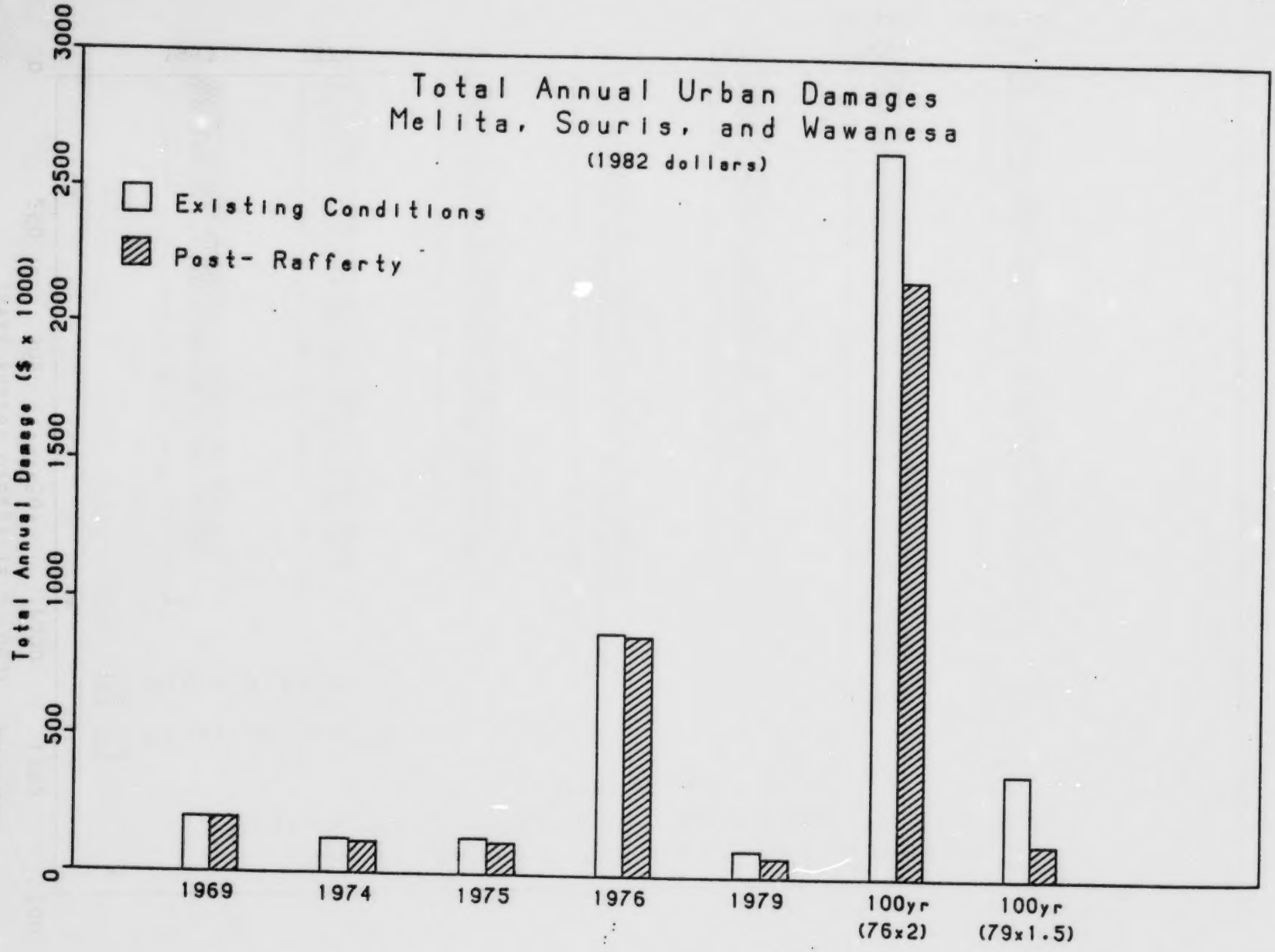

Total Annual Urban Damages
Melita, Souris, and Wawanesa
(1982 dollars)
Existing Conditions
Post- Rafferty
Total Annual Damage ($ x 1000)
0
500
1000
1500
2000
2500
3000
1969
1974
1975
1976
1979
100yr (76x2)
100yr (79x1.5)

FIGURE 4

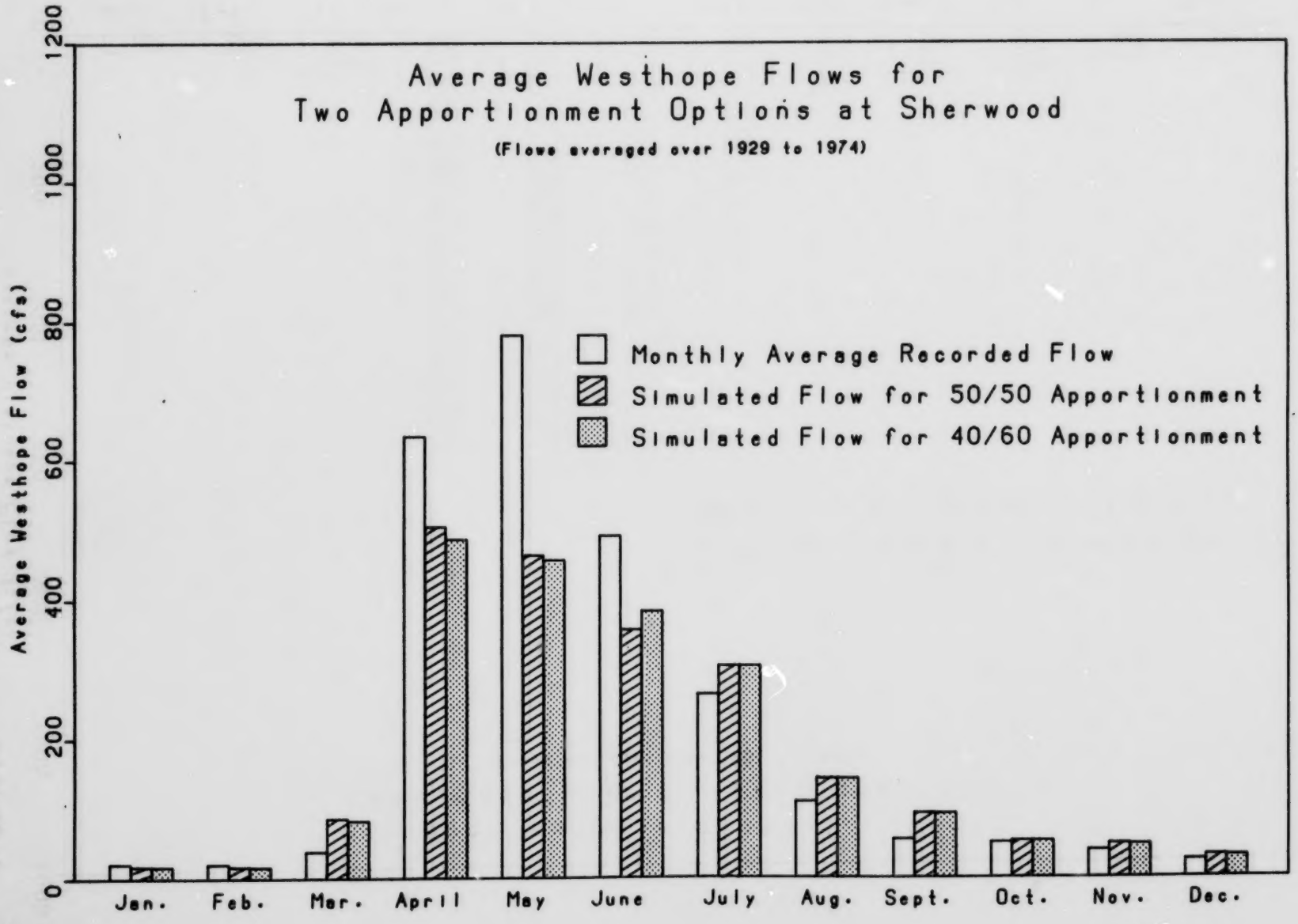

Average Westhope Flows for
Two Apportionment Options at Sherwood
(Flows averaged over 1929 to 1974)
Average Westhope Flow (cfs)
0
200
400
600
800
1000
1200
Monthly Average Recorded Flow
Simulated Flow for 50/50 Apportionment
Simulated Flow for 40/60 Apportionment
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

FIGURE 5

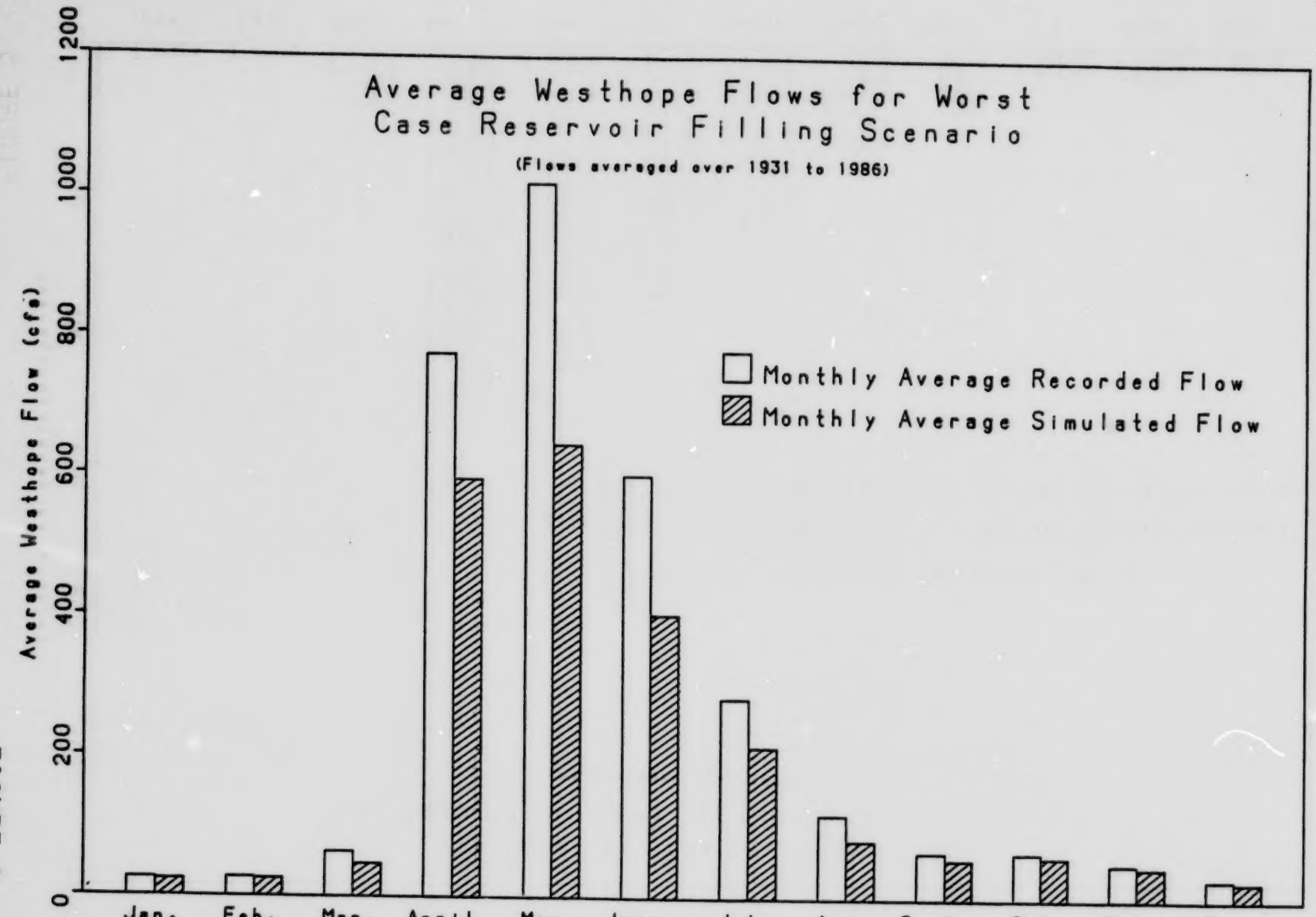

Average Westhope Flows for Worst Case Reservoir Filling Scenario
(Flows averaged over 1931 to 1986)
Average Westhope Flow (cfs)
0
200
400
600
800
1000
1200
Monthly Average Recorded Flow
Monthly Average Simulated Flow
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.

FIGURE 6

TABLE 1
TOTAL AGRICULTURAL DAMAGES (87 data)
WESTHOPE

Year	Band	Sim. Existing	Rafferty	Diff.	Modified Lake Darling	Diff.
		A	B	C=B-A	D	E=D-A
1969	Lower	15552	15552	0	16108	556
	Middle	22920	23148	228	22980	60
	Upper	7763	6919	-844	7459	-304
	Total	46235	45619	-616	46547	312
1974	Lower	15830	13546	-2284	13597	-2233
	Middle	29831	28601	-1230	29603	-228
	Upper	7549	5916	-1633	7449	-100
	Total	53210	48063	-5147	50649	-2561
1975	Lower	18830	18830	0	18990	160
	Middle	36480	35949	-531	38022	1542
	Upper	9150	7839	-1311	10434	1284
	Total	64460	62618	-1842	67446	2986
1976	Lower	15055	14802	-253	15130	75
	Middle	24875	24749	-126	26165	1290
	Upper	10458	10034	-424	10781	323
	Total	50388	49585	-803	52076	1688
1979	Lower	17389	16310	-1079	17347	-42
	Middle	30260	28863	-1397	31187	927
	Upper	8025	6365	-1660	7622	-403
	Total	55674	51538	-4136	56156	482
AVERAGE ANNUAL 1936 - 1985						
	Lower	1855	1785	-70	1824	-31
	Middle	3238	3180	-59	3325	87
	Upper	881	769	-113	889	8
	Total	5974	5733	-241	6038	63
	Gross			5		137

(Note: 1982 Dollars)

TABLE 2
TOTAL AGRICULTURAL DAMAGES (87 data)
PENINSULA BRIDGE

Year	Band	Sim. Existing	Rafferty	Diff.	Modified Lake Darling	Diff.
		A	B	C=B-A	D	E=D-A
1969	Lower	18734	18835	101	19063	329
	Middle	92961	93340	379	93008	47
	Upper	37694	42728	5034	38218	524
	Total	149389	154903	5514	150289	900
1974	Lower	21262	21186	-76	21330	68
	Middle	95420	93585	-1835	95099	-321
	Upper	44551	40967	-3584	46675	2124
	Total	161233	155738	-5495	163104	1871
1975	Lower	21834	21380	-454	22956	1122
	Middle	96729	96416	-313	97041	312
	Upper	52504	39336	-13168	57145	4641
	Total	171067	157132	-13935	177142	6075
1976	Lower	19897	19813	-84	20082	185
	Middle	93942	94162	220	94641	699
	Upper	78461	73935	-4526	76812	-1649
	Total	192300	187910	-4390	191535	-765
1979	Lower	21515	21169	-346	22324	809
	Middle	94114	93844	-270	95959	1845
	Upper	40113	29590	-10523	46847	6734
	Total	155742	144603	-11139	165130	9388
AVERAGE ANNUAL 1936 - 1985						
	Lower	2333	2316	-16	2400	68
	Middle	10881	10846	-35	10927	46
	Upper	5015	4499	-515	5337	323
	Total	18228	17661	-566	18664	436
	Gross			110		477

(Note: 1982 Dollars)

TABLE 3
TOTAL AGRICULTURAL DAMAGES (87)
MELITA

Year	Band	Sim. Existing	Rafferty	Diff.	Modified Lake Darling	Diff.
		A	B	C=B-A	D	E=D-A
1969	Lower	142943	142994	51	143137	194
	Middle	269655	186036	-83619	253767	-15888
	Upper	6367	3622	-2745	7607	1240
	Total	418965	332652	-86313	404511	-14454
1974	Lower	145629	145494	-135	145561	-68
	Middle	239684	222859	-16825	247488	7804
	Upper	0	0	0	3397	3397
	Total	385313	368353	-16960	396446	11133
1975	Lower	148106	147726	-380	148552	446
	Middle	278852	241239	-37613	290143	11291
	Upper	0	0	0	9831	9831
	Total	426958	388965	-37993	448526	21568
1976	Lower	143855	143780	-75	144303	448
	Middle	289382	237928	-51454	289933	551
	Upper	20995	5217	-15778	26427	5432
	Total	454232	386925	-67307	460663	6431
1979	Lower	146381	145857	-524	146870	489
	Middle	253973	212886	-41087	267501	13528
	Upper	0	0	0	0	0
	Total	400354	358743	-41611	414371	14017
AVERAGE ANNUAL 1936 - 1985						
	Lower	16714	16693	-21	16774	61
	Middle	28875	24441	-4434	29111	236
	Upper	526	170	-356	909	382
	Total	46115	41304	-4811	46795	680
	Gross			1		1084

(Note: 1982 Dollars)

TABLE 4
TOTAL AGRICULTURAL DAMAGES (87 data)
LAUDER

Year	Band	Sim. Existing	Rafferty	Diff.	Modified Lake Darling	Diff.
		A	B	C=B-A	D	E=D-A
1969	Lower	119201	119252	51	119411	210
	Middle	166482	166177	-305	165864	-618
	Upper	14626	14459	-167	14728	102
	Total	300309	299888	-421	300003	-306
1974	Lower	123002	122799	-203	122967	-35
	Middle	170390	167639	-2751	169717	-673
	Upper	4706	2520	-2186	10248	5542
	Total	298098	292958	-5140	302932	4834
1975	Lower	127578	127240	-338	127501	-77
	Middle	174137	171189	-2948	174224	87
	Upper	2822	0	-2822	12446	9624
	Total	304537	298429	-6108	314171	9634
1976	Lower	120878	120769	-109	121265	387
	Middle	168378	168187	-191	170137	1759
	Upper	57404	8809	-48595	57039	-365
	Total	346660	297765	-48895	348441	1781
1979	Lower	124224	123381	-843	124737	513
	Middle	166832	160364	-6468	171719	4887
	Upper	0	63	63	0	0
	Total	291056	283808	-7248	296456	5400
AVERAGE ANNUAL 1936 - 1985						
	Lower	14117	14089	-28	14168	51
	Middle	19083	18840	-243	19168	85
	Upper	1530	497	-1033	1817	287
	Total	34729	33426	-1304	35152	422
	Gross			9		475

(Note: 1982 Dollars)

TABLE 5
TOTAL AGRICULTURAL DAMAGES (87 data)
HARTNEY

Year	Band	Sim. Existing	Rafferty	Diff.	Modified Lake Darling	Diff.
		A	B	C=B-A	D	E=D-A
1969	Lower	29179	29054	-125	28816	-363
	Middle	19207	18837	-370	18855	-352
	Upper	0	-40	-40	0	0
	Total	48386	47851	-535	47671	-715
1974	Lower	31607	29972	-1635	31128	-479
	Middle	12607	11806	-801	14812	2205
	Upper	0	0	0	0	0
	Total	44214	41778	-2436	45940	1726
1975	Lower	33272	32272	-1000	33358	86
	Middle	11028	8221	-2807	16934	5906
	Upper	0	-50	-50	0	0
	Total	44300	40443	-3857	50292	5992
1976	Lower	30596	30582	-14	30966	370
	Middle	29091	12210	-16881	29285	194
	Upper	3702	0	-3702	2990	-712
	Total	63389	42792	-20597	63241	-148
1979	Lower	31224	30275	-949	32138	914
	Middle	6406	2698	-3708	8487	2081
	Upper	0	0	0	0	0
	Total	37630	32973	-4657	40625	2995
AVERAGE ANNUAL 1936 - 1985						
	Lower	3470	3398	-71	3472	1
	Middle	1507	1034	-473	1699	193
	Upper	71	-2	-73	58	-14
	Total	5048	4431	-617	5229	181
	Gross			5		226

(Note: 1982 Dollars)

TABLE 6
Rafferty/Alameda Impact Analysis
Urban Damages (1982 dollars)

	Melita			Souris			Wawanesa		
	Flow	Level	Damage	Flow	Level	Damage	Flow	Level	Damage
1969 Rafferty	9633	1409.6	200200	9990	1354.5	0	10062	1153.5	0
Existing	9643	1409.6	200500	9831	1354.4	0	9910	1153.4	0
Difference	-10	0.0	-300	159	0.1	0	152	0.1	0
1974 Rafferty	6842	1408.8	116200	7782	1353.2	0	10193	1153.6	0
Existing	7122	1408.9	125500	7814	1353.2	0	9781	1153.3	0
Difference	-280	-0.1	-9300	-32	0.0	0	412	0.3	0
1975 Rafferty	6715	1408.7	115800	7580	1353.1	0	7579	1151.6	0
Existing	7166	1408.9	132000	7963	1353.3	0	7955	1151.9	0
Difference	-451	-.2	-16200	-383	-.2	0	-376	-.3	0
1976 Rafferty	17655	1411.2	377700	24991	1364.6	404900	25765	1162.1	94600
Existing	16645	1411.0	361300	25095	1364.6	418700	26005	1162.2	107700
Difference	1010	0.2	16400	-104	0.0	-13800	-237	-0.1	-13100
1979 Rafferty	5560	1408.1	70400	5736	1352.0	0	5779	1150.2	0
Existing	6245	1408.4	95700	6427	1352.4	0	6457	1150.8	0
Difference	-685	-.3	-25300	-691	-.4	0	-687	-.6	0
Average Annual Damage Increment 1936-1987			-667			-265			-252

TABLE 7

Rafferty/Alameda Damage Increment Summary

	Net Damages			Gross Damages *		
Year	Agricultural	Urban	Total	Agricultural	Urban	Total
1969	-82371	-300	-82671	5488	0	5488
1974	-35178	-9300	-44478	0	0	0
1975	-63735	-16200	-79935	0	0	0
1976	-141992	-10500	-152492	220	16400	16620
1979	-68791	-25300	-94091	63	0	0
Total	-392067	-61600	-453667	5771	16400	22108
Average Annual 1936 - 1987	-7539	-1185	-8724	110	4789	425

* Difference between damages with Rafferty and Alameda operation, and without project operation except that benefits are ignored.

TABLE 8
100 YEAR FLOOD
AGRICULTURAL DAMAGES

Reach	Band	1976 x 1.5 Simulated Existing	1976 x 1.5 Rafferty	1976 x 1.5 Diff.	1979 x 2 Simulated Existing	1979 x 2 Rafferty	1979 x 2 Diff.
Westhope	Lower	17187	15189	-1998	18990	18990	0
	Middle	32401	27590	-4811	42985	35098	-7887
	Upper	11987	12841	854	15182	11104	-4078
	Total	61575	55620	-5955	77157	65192	-11965
Penn. Br	Lower	20664	20681	17	25905	22998	-2907
	Middle	95528	95644	116	102962	106668	-3706
	Upper	95772	83780	-11992	89197	50282	-38915
	Total	211964	200105	-11859	218064	172536	-45528
Melita	Lower	145835	144691	-1144	149428	147748	-1680
	Middle	288116	290478	2362	292616	279280	-13336
	Upper	50397	29533	-20864	79849	0	-79849
	Total	484348	464738	-19646	521893	427028	-94865
Lauder	Lower	123971	121931	-2040	127797	121931	-5866
	Middle	171821	172312	491	183378	180342	-3036
	Upper	52665	76542	23877	65676	2653	-63023
	Total	348457	370785	22328	376851	304926	-71925
Hartney	Lower	31914	32124	210	37400	34022	-3378
	Middle	30422	30878	456	34678	11626	-23052
	Upper	5223	4906	-317	3527	0	-3527
	Total	67559	67908	349	75605	45648	-29957
Total Agricultural Damage		1173903	1159156	-14747	1269570	1015330	-254240

(Note: 1982 Dollars)

TABLE 9
100 YEAR FLOOD
URBAN DAMAGES

Community	1976 x 1.5			1979 x 2		
	Peak Flow	Peak Level	Damage	Peak Flow	Peak Level	Damage
Melita						
Rafferty	21492	1411.9	435100	7157	1408.8	127500
Existing	23078	1412.1	460700	15916	1410.9	350200
Difference	-1586	-.2	-25600	-8759	-2.1	-222700
Souris						
Rafferty	30029	1366.3	1146500	7303	1352.9	0
Existing	31455	1366.8	1351600	15880	1359.3	35000
Difference	-1426	-.5	-205100	-8577	-6.4	-35000
Wawanesa						
Rafferty	31232	1165.1	607900	7362	1151.5	0
Existing	32775	1165.7	850000	15874	1157.2	0
Difference	-1543	-.6	-242100	-8512	-5.7	0
Total Urban Damage						
Rafferty			2189500			127500
Existing			2662300			385200
Difference			-472800			-257700

(Note: 1982 Dollars)

Table 10

SOURIS RIVER AT WESTHOPE - SIMULATED MONTHLY FLOWS (M3/S) WITH 50/50 APPORTIONMENT AT SHERWOOD

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VOL(A.FT.)
1912	8.9	7.6	104	407	769	165	264	124	65.9	21.6	44.2	41.7	168	123212.
1913	0.00	37.3	101	49.1	309	110	20.0	20.0	20.0	20.0	0.00	0.39	57.3	41733.
1914	28.3	3.3	0.00	0.71	124	20.0	20.0	28.6	88.8	20.0	0.00	10.1	28.7	20906.
1915	0.00	6.7	19.2	0.71	0.64	20.0	20.0	20.0	20.0	20.0	8.7	0.00	11.3	8219.
1916	20.5	0.00	0.00	0.71	0.64	512	760	20.0	94.3	20.0	0.00	16.8	120	87705.
1917	0.00	16.3	53.0	0.71	47.8	123	46.2	20.0	20.0	20.0	0.00	0.11	29.0	20983.
1918	12.4	2.3	0.00	0.71	0.64	20.0	20.0	20.0	20.0	20.0	0.00	0.00	9.7	7033.
1919	0.00	0.00	33.0	0.71	390	20.0	20.0	20.0	20.0	20.0	19.0	0.00	45.2	33253.
1920	28.5	1.5	22.5	0.71	0.64	305	292	24.1	24.0	20.0	3.4	0.00	60.3	43809.
1921	8.2	29.0	58.4	0.71	0.64	103	24.5	20.0	39.7	20.0	7.7	0.00	26.1	18757.
1922	5.8	7.8	0.00	0.71	565	20.0	20.0	20.0	20.0	20.0	10.3	18.2	59.0	43411.
1923	18.8	14.7	29.3	0.71	122	683	641	20.0	176	36.4	19.1	26.5	149	108257.
1924	20.8	11.3	68.3	174	0.64	45.9	20.0	25.3	20.0	20.0	0.00	88.5	41.3	29916.
1925	45.2	11.9	98.5	0.71	337	442	319	33.7	20.0	20.0	0.00	32.1	113	82741.
1926	20.5	22.2	66.7	0.71	0.64	20.0	20.0	20.0	20.0	51.7	0.00	18.6	21.8	15846.
1927	12.7	18.7	56.2	46.6	0.60	1035	1071	735	232	128	120	105	297	216227.
1928	5.4	3.6	48.4	0.71	499	328	362	257	430	216	157	144	204	149081.
1929	19.0	9.6	67.7	101	47.5	20.0	20.0	20.0	20.0	20.0	0.00	3.7	29.1	21128.
1930	19.0	14.6	47.3	299	115	40.7	40.7	20.0	20.0	20.0	3.1	4.4	53.7	38829.
1931	0.00	0.99	0.00	0.71	0.64	20.0	20.0	20.0	20.0	20.0	0.00	0.00	8.5	6203.
1932	1.7	1.5	0.00	0.71	9.0	22.6	22.6	20.0	20.0	20.0	0.00	0.00	9.8	7166.
1933	0.18	0.00	0.00	240	46.0	20.0	20.0	101	23.1	20.0	0.00	2.5	39.5	28568.
1934	0.60	0.00	0.00	0.71	11.0	20.0	20.0	20.0	20.0	20.0	0.00	0.00	9.4	6821.
1935	0.00	0.60	18.2	0.71	16.2	22.5	22.5	88.8	30.9	20.0	0.00	0.00	18.4	13440.
1936	0.00	0.60	21.5	0.71	64.6	31.6	31.6	20.0	20.0	20.0	1.4	0.00	17.7	12925.
1937	0.00	0.00	2.1	0.71	17.7	20.0	20.0	20.0	20.0	20.0	4.0	0.00	10.4	7564.
1938	0.00	0.00	0.00	20.7	0.64	20.0	20.0	20.0	20.0	20.0	0.00	0.00	10.1	7339.
1939	0.00	0.00	0.00	0.71	0.64	20.0	20.0	20.0	27.4	20.0	7.1	0.00	9.6	7009.
1940	0.00	0.00	0.00	47.7	54.6	20.0	20.0	20.0	20.0	20.0	0.00	0.00	16.9	12263.
1941	0.00	0.00	11.3	72.6	0.64	50.1	50.1	20.0	20.0	55.1	159	0.00	36.6	26398.
1942	0.00	13.8	163	461	227	20.0	20.0	20.0	20.0	20.0	4.7	9.6	81.8	59237.
1943	44.4	2.8	210	0.70	1350	699	593	448	78.8	61.8	25.1	14.7	294	215422.
1944	0.00	12.9	67.9	0.71	184	491	382	835	235	227	23.4	13.0	206	150592.
1945	9.6	7.8	411	441	114	78.4	22.8	41.9	55.7	35.4	54.5	14.4	107	77875.
1946	10.4	18.4	143	179	32.9	20.0	20.0	20.0	20.0	20.0	28.1	9.0	43.4	31440.
1947	12.6	0.00	131	167	383	263	39.6	115	63.8	22.5	31.2	23.4	104	76011.
1948	19.6	66.6	9.7	1143	1135	1315	1368	109	101	20.0	109	38.8	453	328829.
1949	33.2	0.00	29.5	3265	597	375	448	69.8	20.0	20.0	29.0	0.00	407	293275.
1950	30.7	0.00	327	264	1469	1258	1074	178	136	20.0	53.4	0.00	401	292550.
1951	43.3	64.9	0.00	2225	1038	1200	1125	177	36.9	70.5	12.2	0.00	499	361381.
1952	33.2	123	0.60	894	277	30.2	65.6	69.8	20.0	20.0	23.2	5.0	130	93716.
1953	16.9	32.8	155	126	361	484	393	29.4	771	60.1	0.64	135	214	155061.
1954	52.9	1.2	124	247	91.0	936	780	1205	288	107	268	97.4	350	254826.
1955	77.4	41.8	180	1830	1043	1069	624	254	20.0	20.0	67.0	75.4	441	319914.
1956	54.7	55.1	0.00	724	1531	1477	658	20.0	20.0	25.4	37.3	85.1	390	283652.
1957	3.5	5.2	112	70.8	0.64	85.6	45.4	20.0	20.0	32.8	0.00	24.5	35.0	25466.
1958	0.00	0.00	43.4	0.71	8.2	86.6	86.6	20.0	20.0	28.2	28.6	34.8	29.8	21683.
1959	3.8	0.00	54.1	0.71	0.64	50.3	20.0	20.0	154	37.6	126	75.4	45.3	32765.
1960	16.0	0.00	0.00	952	797	189	186	48.6	20.0	31.9	0.00	7.3	187	136086.
1961	8.0	29.0	35.0	29.2	0.64	20.0	20.0	20.0	20.0	20.0	22.9	2.7	19.0	13628.
1962	7.7	9.5	0.00	0.71	17.1	47.6	27.3	51.4	20.0	39.7	25.7	3.6	20.9	15150.
1963	0.00	4.3	46.4	36.6	11.1	147	170	114	20.0	52.7	42.8	49.7	58.1	42339.
1964	5.2	0.88	138	0.71	139	176	156	85.7	120	20.0	73.9	36.2	79.5	57916.
1965	19.1	0.00	80.4	66.3	331	27.6	20.0	136	299	196	223	22.8	118	86300.
1966	19.2	4.7	123	199	332	131	125	35.8	20.0	44.8	103	0.00	94.9	69114.
1967	30.2	39.8	221	315	232	20.0	20.0	20.0	20.0	20.0	0.46	7.7	79.0	57374.
1968	16.2	0.00	58.9	77.1	21.2	20.0	20.0	82.0	223	154	85.7	54.0	67.7	49168.
1969	49.9	21.1	0.00	3215	2307	1070	1160	20.0	327	20.0	0.00	39.7	685	496885.
1970	30.5	0.00	146	352	1836	1480	1489	631	271	45.1	7.8	85.6	531	387912.
1971	24.7	47.8	43.1	301	559	361	261	24.0	251	206	154	116	196	142263.
1972	51.3	76.3	599	1924	1400	240	135	453	47.1	112	172	149	446	324622.
1973	0.00	28.4	79.0	32.9	98.5	20.0	20.0	145	100	220	155	52.2	79.3	57759.
1974	38.6	35.6	0.00	2483	2589	1822	1790	501	47.5	44.5	0.00	129	790	574307.

MONTHLY SUMMARY FOR PERIOD OF RECORD

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VOL(A.FT.)
MIN	0.00	0.00	0.00	0.70	0.60	20.0	20.0	20.0	20.0	20.0	0.00	0.00	8.5	6203.
MAX	77.4	123	599	3265	2589	1822	1790	1205	771	227	268	149	790	574307.
MEAN	16.5	15.3	74.0	373	382	317	280	124	87.4	48.7	40.6	30.6	149	108433.

Table 11

SOURIS RIVER AT WESTHOPE - SIMULATED MONTHLY FLOWS (CSF) WITH 40/60 APPORTIONMENT AT SHERWOOD

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VOL(A.FT.)
1912	8.9	7.6	98.1	370	769	165	264	124	65.9	21.6	44.2	41.7	165	120604.
1913	0.00	37.3	101	49.0	309	110	20.0	20.0	20.0	20.0	0.00	0.39	57.3	41729.
1914	28.3	3.3	0.00	0.71	124	20.0	20.0	28.6	88.8	20.0	0.00	10.1	28.7	20906.
1915	0.00	6.7	19.2	0.71	0.64	20.0	20.0	20.0	20.0	20.0	8.7	0.00	11.3	8219.
1916	20.5	0.00	0.00	0.71	0.64	444	760	20.0	94.3	20.0	0.00	16.8	114	83635.
1917	0.00	16.3	53.0	0.71	47.8	123	46.2	20.0	20.0	20.0	0.00	0.11	29.0	20983.
1918	12.4	2.3	0.00	0.71	0.64	20.0	20.0	20.0	20.0	20.0	0.00	0.00	9.7	7033.
1919	0.00	0.00	33.0	0.71	248	20.0	20.0	20.0	20.0	20.0	19.0	0.00	33.4	24528.
1920	28.5	1.5	22.5	0.71	0.64	305	292	24.1	24.0	20.0	3.4	0.00	60.3	43809.
1921	8.2	19.3	26.1	0.71	0.64	103	24.5	20.0	39.7	20.0	7.7	0.00	22.6	16232.
1922	5.8	7.8	0.00	0.71	565	20.0	20.0	20.0	20.0	20.0	10.3	18.2	59.0	43411.
1923	16.8	12.0	27.5	0.71	122	683	641	20.0	176	36.4	19.1	26.5	148	107871.
1924	20.8	11.3	68.3	174	0.64	45.9	20.0	25.3	20.0	20.0	0.00	88.5	41.3	29916.
1925	45.2	11.9	98.5	0.71	337	442	319	33.7	20.0	20.0	0.00	32.1	113	82741.
1926	20.5	22.2	66.7	0.71	0.64	20.0	20.0	20.0	20.0	51.7	0.00	11.2	21.1	15387.
1927	8.3	11.9	23.4	46.6	0.60	1035	1071	735	232	128	120	105	293	213562.
1928	5.4	3.6	48.4	0.71	499	328	406	257	417	146	81.5	47.3	186	136283.
1929	13.2	9.6	61.2	73.7	20.6	20.0	20.0	20.0	20.0	20.0	0.00	3.7	23.5	17055.
1930	19.0	14.6	47.3	299	115	40.7	40.7	20.0	20.0	20.0	3.1	4.4	53.7	38829.
1931	0.00	0.99	0.00	0.71	0.64	20.0	20.0	20.0	20.0	20.0	0.00	0.00	8.5	6203.
1932	0.78	1.5	0.00	0.71	9.0	22.6	22.6	20.0	20.0	20.0	0.00	0.00	9.8	7112.
1933	0.18	0.00	0.00	240	46.0	20.0	20.0	101	23.1	20.0	0.00	2.5	39.5	28568.
1934	0.60	0.00	0.00	0.71	11.0	20.0	20.0	20.0	20.0	20.0	0.00	0.00	9.4	6821.
1935	0.00	0.60	18.2	0.71	16.2	22.5	22.5	88.8	30.9	20.0	0.00	0.00	18.4	13440.
1936	0.00	0.60	21.5	0.71	64.6	31.6	31.6	20.0	20.0	20.0	1.4	0.00	17.7	12925.
1937	0.00	0.00	2.1	0.71	17.7	20.0	20.0	20.0	20.0	20.0	4.0	0.00	10.4	7564.
1938	0.00	0.00	0.00	20.7	0.64	20.0	20.0	20.0	20.0	20.0	0.00	0.00	10.1	7339.
1939	0.00	0.00	0.00	0.71	0.64	20.0	20.0	20.0	27.4	20.0	7.1	0.00	9.6	7009.
1940	0.00	0.00	0.00	47.7	53.6	20.0	20.0	20.0	20.0	20.0	0.00	0.00	16.8	12202.
1941	0.00	0.00	11.3	72.6	0.64	50.1	50.1	20.0	20.0	55.1	146	0.00	35.5	25646.
1942	0.00	13.8	163	452	212	20.0	20.0	20.0	20.0	20.0	4.7	9.6	79.7	57761.
1943	34.9	2.6	201	0.70	1350	699	593	448	78.8	61.8	25.1	14.7	292	214231.
1944	0.00	12.9	67.9	0.71	184	491	382	835	235	227	23.4	13.0	206	150592.
1945	9.6	7.8	411	441	114	78.4	22.8	41.9	55.7	35.4	54.5	14.4	107	77875.
1946	10.4	18.4	143	179	32.9	20.0	20.0	20.0	20.0	20.0	23.9	4.5	42.7	30909.
1947	12.6	0.00	131	167	383	263	39.6	115	63.8	22.5	31.2	23.4	104	76011.
1948	18.9	47.4	9.7	528	1135	1315	1368	109	101	20.0	109	38.8	400	291069.
1949	33.2	0.00	29.5	3263	597	375	448	69.8	20.0	20.0	29.0	0.00	407	293174.
1950	30.7	0.00	327	264	1458	1258	1074	178	136	20.0	53.4	0.00	400	291849.
1951	43.3	64.9	0.00	2225	1038	1200	1125	177	36.9	70.5	12.2	0.00	499	361381.
1952	33.2	123	0.00	836	277	30.2	65.6	69.8	20.0	20.0	23.2	5.0	125	90201.
1953	16.9	32.8	155	126	361	358	393	29.4	771	60.1	0.64	135	203	147536.
1954	52.9	0.30	74.8	218	77.1	922	769	1202	269	97.3	257	86.8	335	244418.
1955	77.4	41.8	177	1830	1043	1787	663	254	20.0	20.0	67.0	75.4	504	364936.
1956	54.7	55.1	0.00	685	1488	1901	658	20.0	20.0	25.4	37.3	85.1	419	303942.
1957	3.5	5.2	112	70.8	0.64	85.6	45.4	20.0	20.0	32.8	0.00	24.5	35.0	25466.
1958	0.00	0.00	43.4	0.71	8.2	86.6	86.6	20.0	20.0	28.2	28.6	18.8	28.4	20702.
1959	1.8	0.00	19.1	0.71	0.64	50.3	20.0	20.0	154	37.6	126	75.4	42.2	30487.
1960	16.0	0.00	0.00	952	797	189	186	48.6	20.0	31.9	0.00	7.3	187	136086.
1961	8.0	29.0	35.0	29.2	0.64	20.0	20.0	20.0	20.0	20.0	22.9	2.7	19.0	13628.
1962	7.7	9.5	0.00	0.71	17.1	47.6	27.3	51.4	20.0	39.7	25.7	3.6	20.9	15150.
1963	0.00	4.3	46.4	36.6	11.1	115	170	114	20.0	52.7	42.8	49.7	55.4	40445.
1964	5.2	0.88	138	0.71	139	176	156	85.7	120	20.0	57.6	23.5	77.1	56157.
1965	19.1	0.00	80.4	66.3	331	27.6	20.0	136	299	196	223	22.8	118	86300.
1966	19.2	4.7	123	199	332	131	125	35.8	20.0	44.8	103	0.00	94.9	69114.
1967	30.2	39.8	221	315	232	20.0	20.0	20.0	20.0	20.0	0.46	6.8	79.0	57318.
1968	13.1	0.00	58.9	67.6	21.2	20.0	20.0	82.0	223	154	85.7	54.0	66.7	48411.
1969	49.9	21.1	0.00	3210	2307	1070	1160	20.0	327	20.0	0.00	39.7	685	496575.
1970	30.5	0.00	146	352	1602	1480	1489	631	271	45.1	7.8	85.6	511	373517.
1971	24.7	47.8	43.1	252	559	336	261	24.0	251	206	154	116	190	137948.
1972	51.3	76.3	549	1924	1400	426	135	453	47.1	112	172	149	458	332615.
1973	0.00	28.4	79.0	32.9	98.5	20.0	20.0	145	100	220	155	52.2	79.3	57759.
1974	38.6	35.6	0.00	2483	2585	1926	1790	501	47.5	44.5	0.00	129	798	580249.

MONTHLY SUMMARY FOR PERIOD OF RECORD

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VOL(A.FT.)
MIN	0.00	0.00	0.00	0.70	0.60	20.0	20.0	20.0	20.0	20.0	0.00	0.00	8.5	6203.
MAX	77.4	123	549	3263	2585	1926	1790	1202	771	227	257	149	798	580249.
MEAN	16.0	14.7	70.4	359	374	336	281	124	86.9	47.4	38.7	28.2	148	107641.

TABLE 12

SOURIS RIVER NEAR WESTHOPE - MEAN MONTHLY HISTORIC FLOWS IN CFS

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VO
1931	0.50	0.50	0.99	58.5	22.5	4.8	2.2	0.00	0.00	5.3	7.9	2.0	8.8	6323.
1932	0.99	0.99	5.2	73.7	60.5	26.3	12.6	2.1	0.00	0.00	8.4	2.0	16.1	11637.
1933	0.99	0.99	140	874	219	183	209	55.1	10.3	6.2	14.0	3.0	143	103420.
1934	0.99	0.99	71.3	294	56.2	4.6	0.77	0.00	0.00	0.00	0.00	0.00	35.8	25781.
1935	0.00	0.00	6.9	55.5	75.1	17.9	162	68.6	7.8	0.32	0.00	0.00	32.9	24125.
1936	0.00	0.00	0.00	32.1	0.01	7.7	3.7	0.00	0.00	0.00	0.00	0.00	3.6	2594.
1937	0.00	0.00	0.00	1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	110.
1938	0.00	0.00	0.15	0.03	0.00	7.5	0.01	7.8	0.28	0.00	0.00	0.00	1.3	955.
1939	0.00	0.00	0.05	0.21	0.01	8.4	0.00	4.6	1.2	10.2	0.00	0.00	2.1	1500.
1940	0.00	0.00	0.00	0.25	1.0	0.70	2.4	2.6	2.4	3.0	0.02	0.00	1.0	750.
1941	0.00	0.00	0.00	0.01	0.12	6.3	7.3	11.6	16.5	8.6	0.66	0.00	4.3	3098.
1942	0.00	0.00	0.60	408	252	25.7	18.4	28.0	23.3	25.1	0.96	0.00	65.2	47230.
1943	0.00	0.00	0.20	621	2105	1173	827	119	85.3	49.4	12.0	0.10	416	303334.
1944	0.00	5.9	22.9	185	266	294	1293	123	342	94.2	67.2	140	236	172633.
1945	117	72.1	157	754	168	26.2	19.1	89.0	18.2	18.8	0.67	0.00	120	86598.
1946	0.00	0.00	2.0	321	24.3	19.2	15.7	20.7	63.7	12.1	0.52	0.00	39.9	28663.
1947	0.30	1.0	1.0	1042	676	194	382	286	73.3	10.7	10.1	0.80	223	162137.
1948	0.60	0.20	0.50	890	2192	1696	340	247	42.8	19.9	47.0	66.6	462	335626.
1949	32.2	13.5	7.5	3223	1456	612	39.4	39.5	32.4	11.8	1.0	1.3	455	328655.
1950	2.5	3.0	6.1	732	2067	1305	371	149	62.1	27.9	13.3	47.3	399	290267.
1951	121	172	97.4	1844	2493	1520	240	26.6	145	73.0	65.3	162	580	420001.
1952	39.3	27.8	118	784	540	9.8	93.9	76.1	13.7	3.4	24.6	42.6	147	107350.
1953	16.8	13.7	24.9	183	471	794	1210	1013	144	155	176	105	359	262414.
1954	140	135	152	347	238	788	1560	389	71.2	449	182	100	379	276593.
1955	68.0	69.2	71.7	2110	2028	1498	621	280	121	132	7.3	2.8	584	423465.
1956	12.6	15.0	52.6	1028	2383	1021	340	162	140	113	186	55.0	459	334188.
1957	44.7	26.6	37.9	17.7	139	187	72.8	26.5	23.1	22.3	117	51.1	64.0	46346.
1958	17.7	14.1	0.38	7.0	62.1	85.7	32.9	28.7	21.3	14.7	1.0	0.10	23.8	17260.
1959	0.10	0.03	0.94	0.29	0.74	24.9	24.0	19.2	16.4	20.2	64.3	14.6	15.5	11208.
1960	19.8	20.0	58.4	1631	843	453	20.7	13.7	33.0	23.6	5.1	2.1	260	187780.
1961	0.07	0.51	5.4	5.3	10.3	20.7	19.2	10.7	9.7	11.1	3.4	1.0	8.1	5912.
1962	0.00	0.00	0.00	2.0	4.9	4.8	6.5	10.4	10.4	17.0	0.35	0.11	4.7	3434.
1963	0.11	0.11	0.27	0.11	0.40	160	43.2	21.7	20.3	13.1	1.5	0.00	22.6	16325.
1964	0.00	0.00	0.12	0.39	141	44.0	105	17.0	99.4	62.8	0.21	0.10	40.9	29926.
1965	0.08	0.10	0.12	14.9	358	621	166	232	267	204	70.6	48.3	165	120186.
1966	48.6	41.2	106	472	773	174	71.9	39.2	22.5	22.1	6.9	0.12	148	107765.
1967	0.05	0.00	0.25	335	473	91.1	25.8	22.6	17.7	25.2	1.4	0.07	82.7	60142.
1968	0.00	0.00	0.20	0.36	5.7	24.3	19.7	22.1	198	120	31.4	22.5	37.0	26823.
1969	13.1	3.8	6.1	3242	4525	1794	388	500	33.8	24.0	24.9	76.8	886	643723.
1970	86.9	56.7	43.2	499	2344	2726	1191	317	20.1	20.0	11.8	3.3	610	443345.
1971	30.3	57.1	59.1	703	1146	333	347	297	33.5	101	220	97.8	285	207921.
1972	76.4	59.0	310	2383	1610	748	591	98.4	95.5	149	225	22.6	530	384655.
1973	18.6	43.5	26.3	4.6	205	45.2	138	32.3	81.2	105	24.2	23.8	62.5	45532.
1974	23.0	57.7	90.7	2423	4277	3235	776	101	74.7	59.1	104	19.5	936	679413.
1975	22.0	22.8	36.3	1053	5479	4214	1681	237	88.4	472	359	200	1155	841329.
1976	191	190	440	8850	5965	2222	780	525	228	39.9	35.2	52.0	1626	1177079.
1977	39.2	29.1	19.8	0.63	0.18	21.5	21.0	20.8	20.9	21.0	18.7	25.8	19.9	14378.
1978	24.2	26.3	16.8	539	299	56.4	215	219	133	28.2	28.7	33.8	135	98077.
1979	37.2	76.1	107	797	4993	3170	814	153	24.2	28.6	6.3	0.60	850	619362.
1980	7.2	40.5	23.4	99.4	126	24.7	27.0	27.3	43.3	116	111	73.0	60.1	43609.
1981	42.1	26.5	162	247	130	156	48.0	42.3	36.2	32.5	29.4	1.0	79.6	57629.
1982	0.00	0.00	0.00	1004	1753	653	104	135	148	232	257	56.2	362	263095.
1983	58.7	116	779	2410	1644	226	199	191	402	175	114	32.8	529	383632.
1984	19.5	26.5	122	92.7	869	492	205	105	44.7	45.9	62.5	19.0	175	128038.
1985	5.2	3.1	157	294	464	282	59.9	33.0	21.3	86.9	46.7	47.7	125	91126.
1986	40.6	36.4	53.4	443	654	176	40.6	40.5	62.6	188	44.4	25.4	150	109421.

MONTHLY SUMMARY FOR PERIOD OF RECORD

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VO
MIN	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	110.
MAX	191	190	779	8850	5965	4214	1681	1013	402	472	359	200	1626	1177079.
MEAN	25.4	26.9	64.4	775	1019	602	285	120	67.0	66.9	51.0	30.1	261	189713.

TABLE 13

SOURIS RIVER NEAR WESTHOPE - SIMULATED MONTHLY FILL PERIOD FLOWS IN CFS

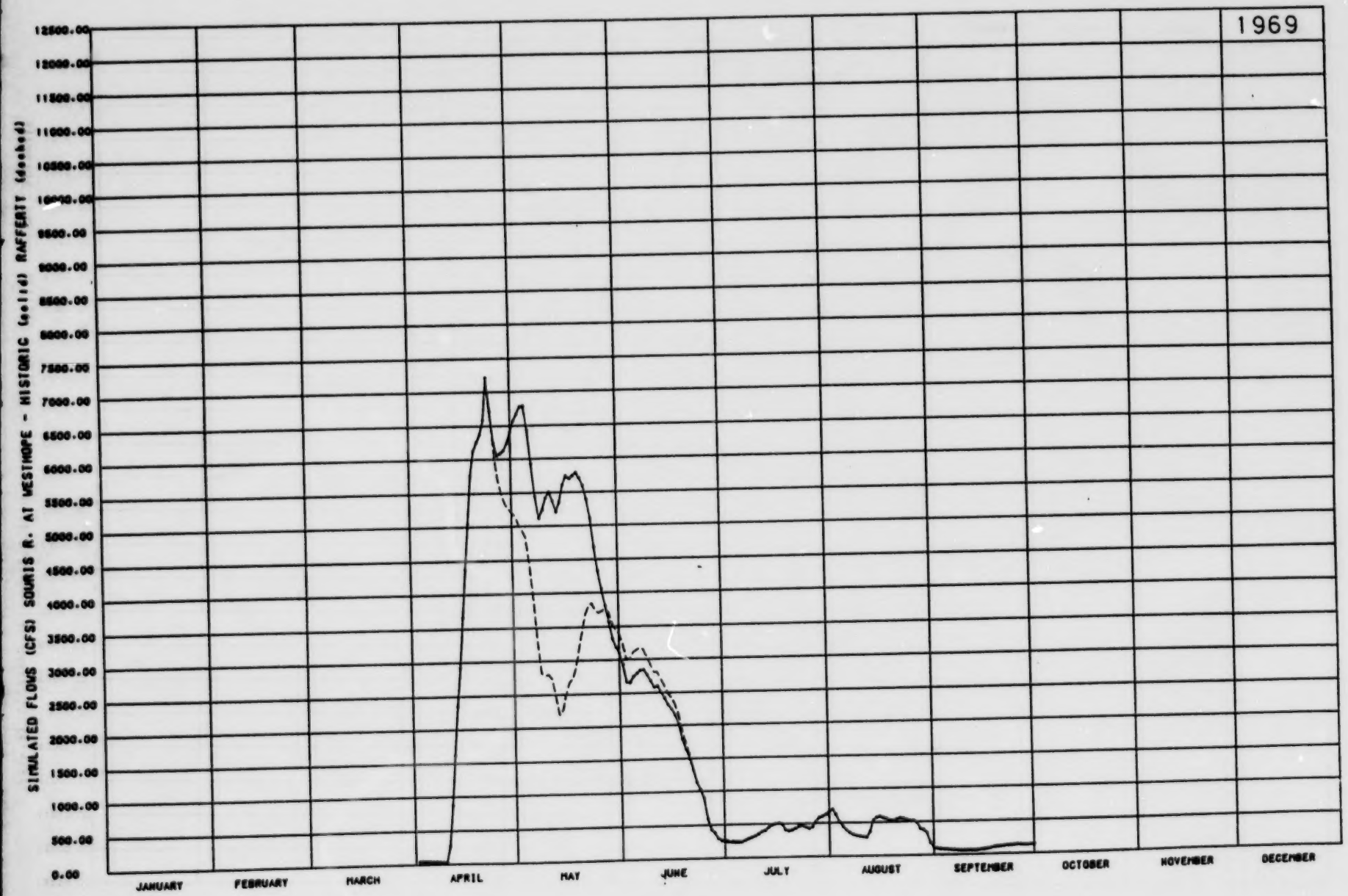
-	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VO
1931	0.50	0.50	0.99	55.7	20.0	4.8	2.2	0.00	0.00	5.3	7.9	2.0	8.3	6004.
1932	0.99	0.99	5.2	62.6	37.1	20.0	12.6	2.1	0.00	0.00	8.4	2.0	12.7	9160.
1933	0.99	0.99	90.1	730	114	85.0	68.8	46.0	10.3	6.2	14.0	3.0	97.6	70316.
1934	0.99	0.99	30.3	198	20.0	4.6	0.77	0.00	0.00	0.00	0.00	0.00	21.3	15325.
1935	0.00	0.00	6.9	44.7	46.8	17.9	150	55.3	7.8	0.32	0.00	0.00	27.5	20178.
1936	0.00	0.00	0.00	20.0	0.01	7.7	3.7	0.00	0.00	0.00	0.00	0.00	2.6	1875.
1937	0.00	0.00	0.00	1.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	110.
1938	0.00	0.00	0.15	0.03	0.00	7.5	0.01	7.8	0.28	0.00	0.00	0.00	1.3	955.
1939	0.00	0.00	0.05	0.21	0.01	8.4	0.00	4.6	1.2	10.2	0.00	0.00	2.1	1500.
1940	0.00	0.00	0.00	0.25	1.0	0.70	2.4	2.6	2.4	3.0	0.02	0.00	1.0	750.
1941	0.00	0.00	0.00	0.01	0.12	6.3	7.3	11.6	16.5	8.6	0.66	0.00	4.3	3098.
1942	0.00	0.00	0.60	229	20.0	20.0	18.4	20.0	20.0	20.0	0.96	0.00	29.1	20946.
1943	0.00	0.00	0.20	49.5	931	1004	741	80.1	71.6	41.5	12.0	0.10	244	178051.
1944	0.00	5.9	20.7	171	233	249	1157	20.0	310	77.6	59.2	135	203	148494.
1945	115	71.1	153	741	152	20.0	19.1	75.0	18.2	18.8	0.67	0.00	115	83243.
1946	0.00	0.00	2.0	42.3	20.0	19.2	15.7	20.0	60.9	12.1	0.52	0.00	16.1	11604.
1947	0.30	1.0	1.0	700	20.0	20.0	266	223	56.7	10.7	10.1	0.80	109	79039.
1948	0.60	0.20	0.50	614	1170	713	254	200	20.9	19.9	40.1	59.0	257	187572.
1949	28.7	13.5	7.5	3057	1111	571	20.0	29.9	27.1	11.8	1.0	1.3	406	292794.
1950	2.5	3.0	6.1	532	1647	1150	306	117	43.8	20.8	13.3	42.7	323	235490.
1951	117	169	94.0	1602	1724	908	171	20.0	134	63.1	53.2	153	434	314115.
1952	35.4	26.1	109	626	234	9.8	78.4	65.2	13.7	3.4	21.3	39.3	105	76239.
1953	16.8	13.7	20.0	81.2	305	546	619	557	65.6	138	167	95.6	218	159795.
1954	133	126	120	274	152	658	1369	319	50.3	421	146	69.1	320	233295.
1955	55.6	64.4	67.7	1682	934	936	430	208	96.7	115	7.3	2.8	383	277182.
1956	12.6	15.0	23.9	626	1575	761	229	54.2	111	103	174	45.0	310	226086.
1957	40.6	24.9	20.0	17.7	20.0	134	52.1	20.0	20.0	20.0	113	46.0	44.1	31845.
1958	17.7	14.1	0.38	7.0	20.0	65.9	27.7	26.9	20.7	14.7	1.0	0.10	18.0	13026.
1959	0.10	0.03	0.94	0.29	0.74	20.0	20.0	19.2	16.4	20.0	50.2	14.6	13.5	9817.
1960	19.8	20.0	37.4	1352	338	387	20.0	13.7	29.0	22.7	5.1	2.1	187	134614.
1961	0.07	0.51	5.4	5.3	10.3	20.0	19.2	10.7	9.7	11.1	3.4	1.0	8.1	5872.
1962	0.00	0.00	0.00	2.0	4.9	4.8	6.5	10.4	10.4	17.0	0.35	0.11	4.7	3434.
1963	0.11	0.11	0.27	0.11	0.40	135	20.0	20.0	20.0	20.0	1.5	0.00	18.2	13094.
1964	0.00	0.00	0.12	0.39	20.0	20.0	84.7	17.0	97.2	81.8	0.21	0.10	26.8	19532.
1965	0.08	0.10	0.12	14.9	178	348	20.0	186	253	198	66.4	44.0	109	79294.
1966	46.4	40.0	20.0	221	603	139	60.7	35.5	21.4	21.7	6.9	0.12	101	73848.
1967	0.05	0.00	0.25	275	313	20.0	20.0	21.3	17.7	25.2	1.4	0.07	57.9	42102.
1968	0.00	0.00	0.20	0.36	5.7	20.0	19.7	21.6	197	119	31.0	22.0	36.4	26385.
1969	13.1	3.8	6.1	2444	2853	1480	315	422	20.0	20.0	20.0	69.3	639	463673.
1970	83.3	53.5	33.0	386	1769	1894	1011	245	20.0	20.0	11.8	3.3	461	335305.
1971	25.3	52.6	46.8	526	765	193	276	197	20.0	60.9	181	80.6	202	147123.
1972	71.3	56.3	79.7	1777	1284	614	441	53.9	59.3	121	214	20.0	399	289285.
1973	18.6	40.3	20.0	4.6	189	30.6	127	30.0	80.3	104	21.2	20.0	57.3	41741.
1974	21.5	57.1	88.0	1885	2827	2406	623	40.8	62.9	53.5	99.4	19.5	682	494095.
1975	20.0	20.0	33.1	812	4203	2478	1379	177	43.5	398	317	171	837	610871.
1976	163	163	310	7278	2975	1452	316	302	175	20.0	23.9	42.2	1101	794725.
1977	33.3	24.7	19.8	0.63	0.18	20.0	20.0	20.0	20.2	20.3	18.7	22.5	18.3	13272.
1978	22.1	25.1	16.8	382	56.1	20.0	66.7	20.0	85.8	20.0	20.0	25.3	63.4	45625.
1979	32.0	73.3	76.8	315	3458	1726	656	113	20.0	22.6	6.3	0.60	541	395236.
1980	7.2	37.3	20.0	43.3	20.0	20.0	24.8	26.1	42.8	116	110	71.4	45.0	32629.
1981	40.5	20.0	96.3	227	124	154	47.4	42.0	35.8	32.3	29.2	1.0	70.9	51330.
1982	0.00	0.00	0.00	669	881	228	59.6	118	141	228	252	51.3	219	159160.
1983	55.5	112	741	2083	971	20.0	150	168	397	174	112	29.7	418	302573.
1984	19.5	23.2	103	51.6	849	485	203	105	44.6	45.6	62.0	19.0	167	122365.
1985	5.2	3.1	92.6	126	374	252	54.8	31.4	20.0	83.5	41.4	44.8	94.2	68617.
1986	39.1	33.8	20.0	352	602	119	20.0	20.0	31.4	185	39.8	20.2	123	89978.

-MONTHLY SUMMARY FOR PERIOD OF RECORD

-	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	MEAN	VO
MIN	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	110.
MAX	163	169	741	7278	4203	2478	1379	557	397	421	317	171	1101	794725.
MEAN	23.5	25.2	47.3	596	646	404	216	83.6	56.7	60.9	46.5	26.7	186	135066.

Attachment A

Hydrographs for 1969, 1974, 1975, 1976,
1979, and for two 100 year floods


1969
SIMULATED FLOWS (CFS) SOURIS R. AT WESTHOPE - HISTORIC (solid) RAFFERTY (dashed)
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12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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6500.00
6000.00
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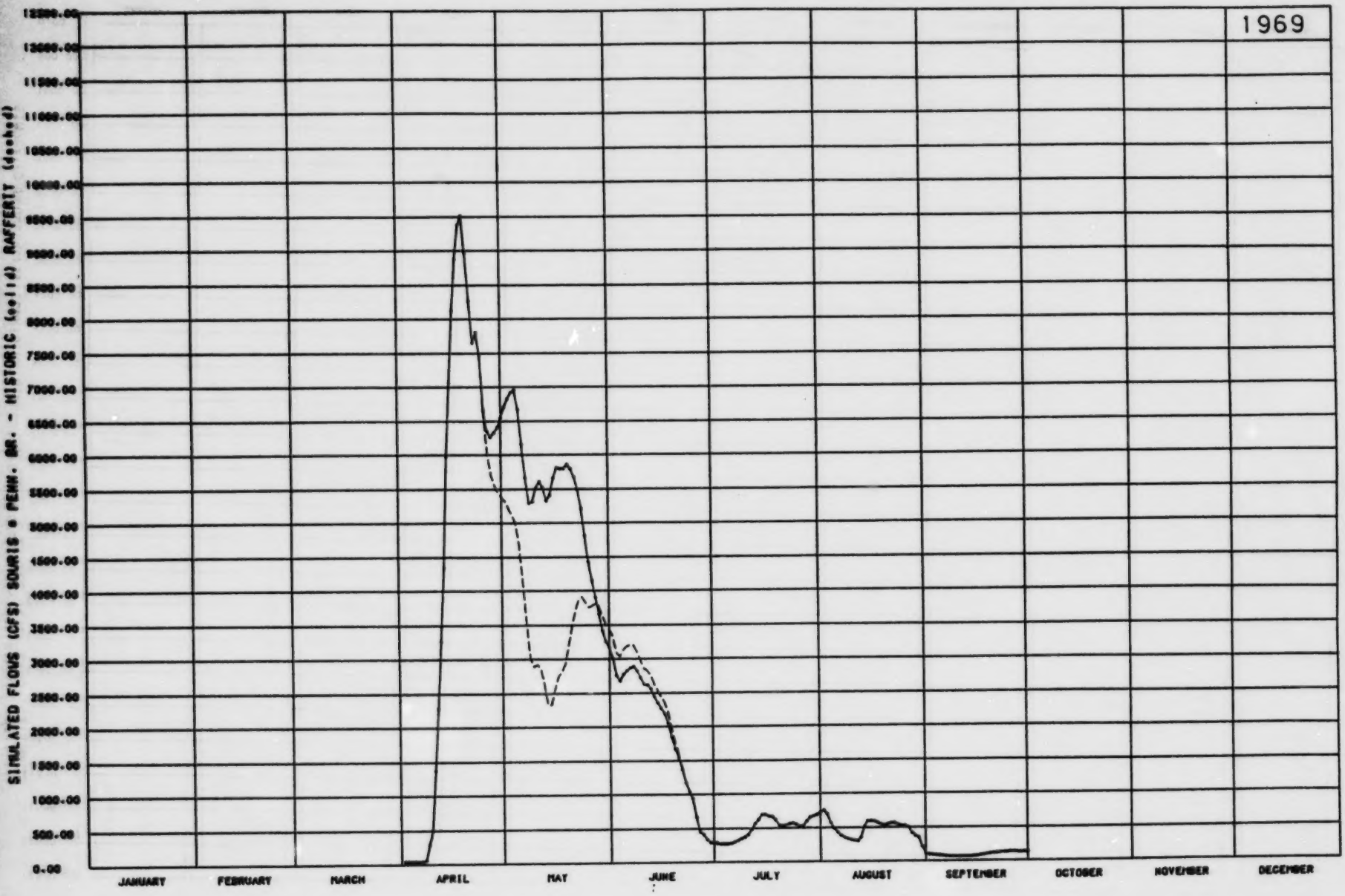
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1969
SIMULATED FLOWS (CFS) SOURIS @ PENN. BR. - HISTORIC (solid) RAFFERTY (dashed)
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12000.00
11500.00
11000.00
10500.00
10000.00
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9000.00
8500.00
8000.00
7500.00
7000.00
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2500.00
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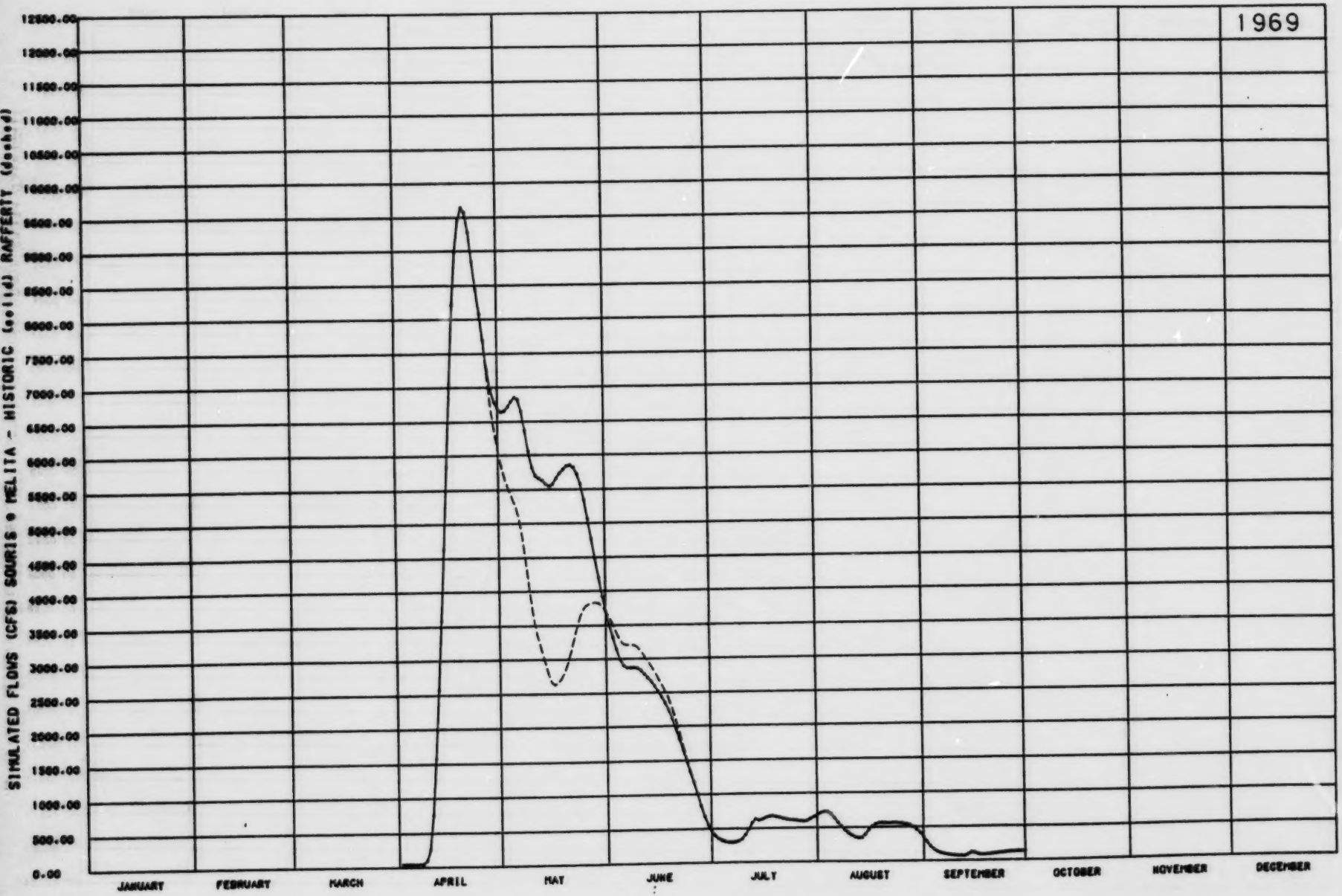
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1969
SIMULATED FLOWS (CFS) SOURIS @ MELITA - HISTORIC (solid) RAFFERTY (dashed)
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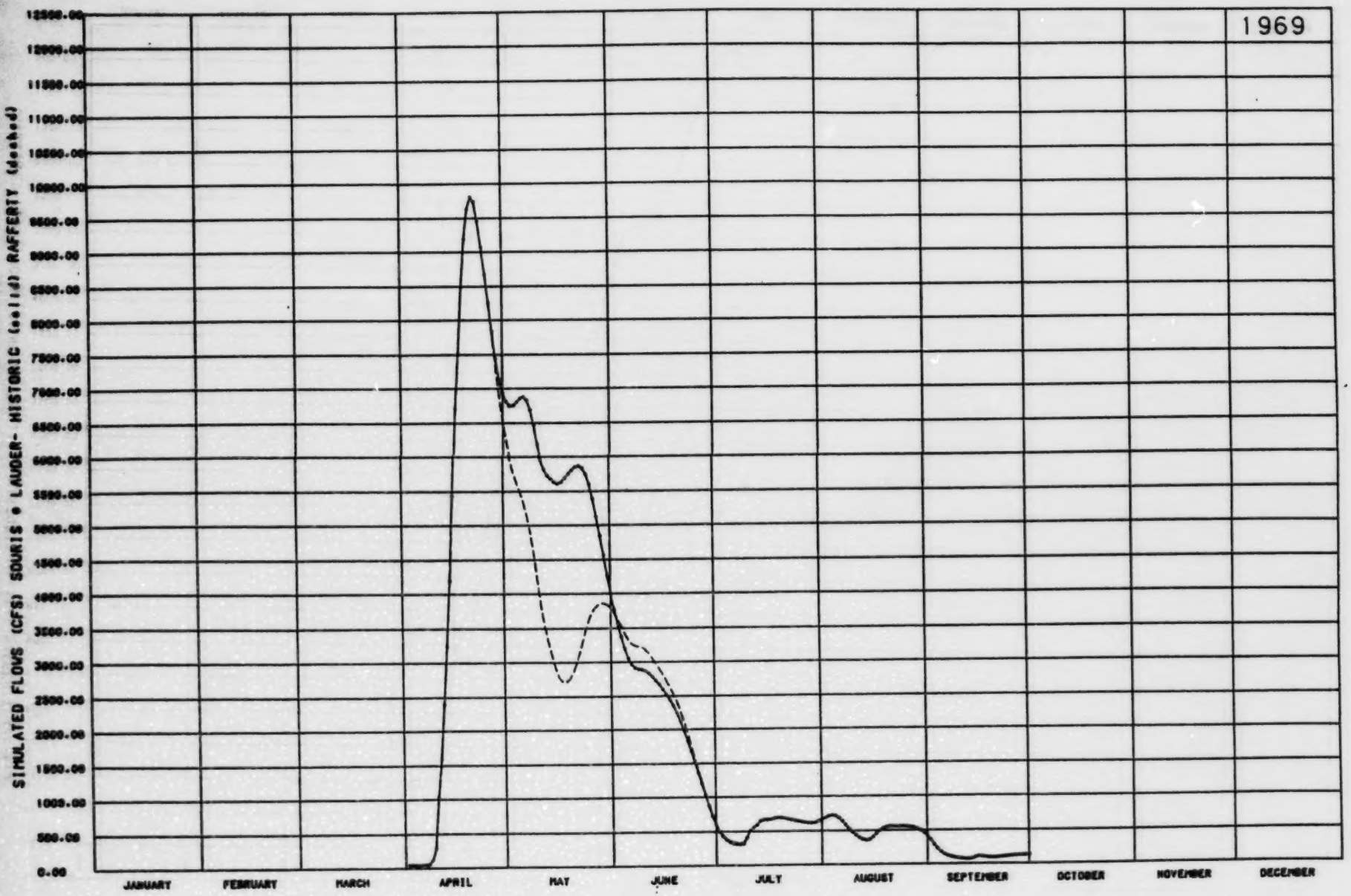
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1969
SIMULATED FLOWS (CFS) SOURIS • LAUDER- HISTORIC (solid) RAFFERTY (dashed)
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12000.00
11500.00
11000.00
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10000.00
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6500.00
6000.00
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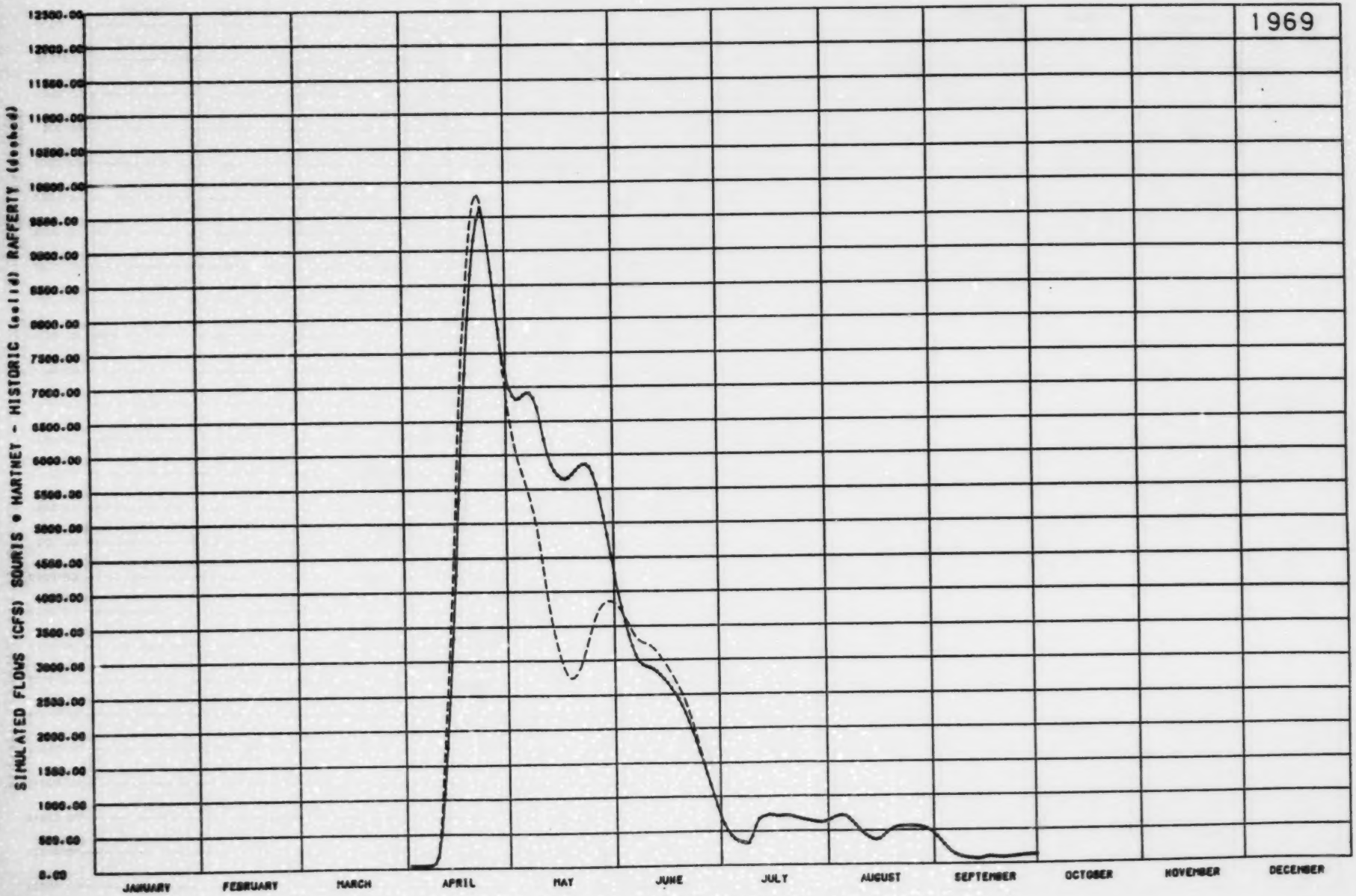
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1969
SIMULATED FLOWS (CFS) SOURIS • HARTNEY - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
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JANUARY
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MARCH
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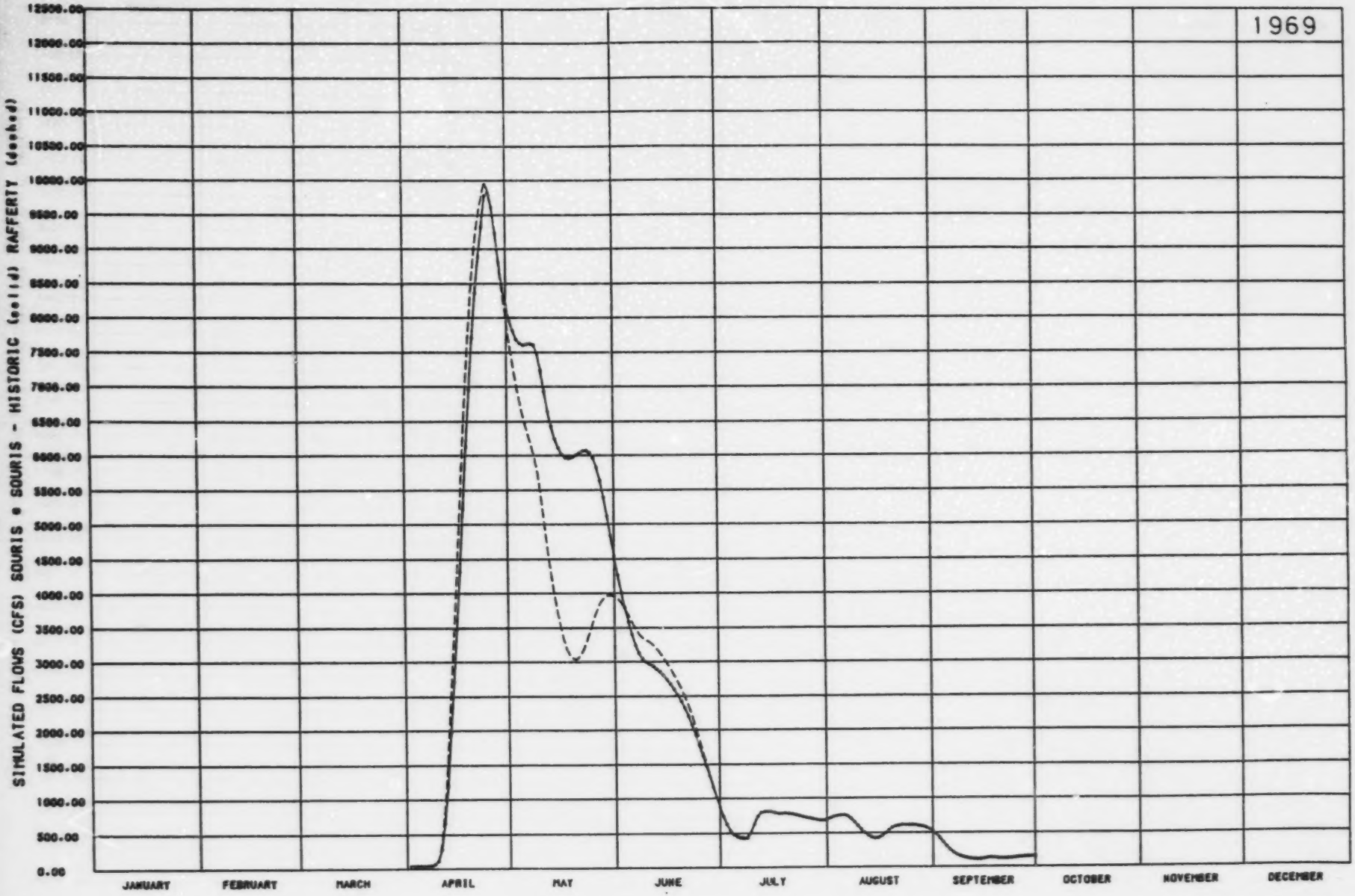
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1969
SIMULATED FLOWS (CFS) SOURIS @ SOURIS - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
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JANUARY
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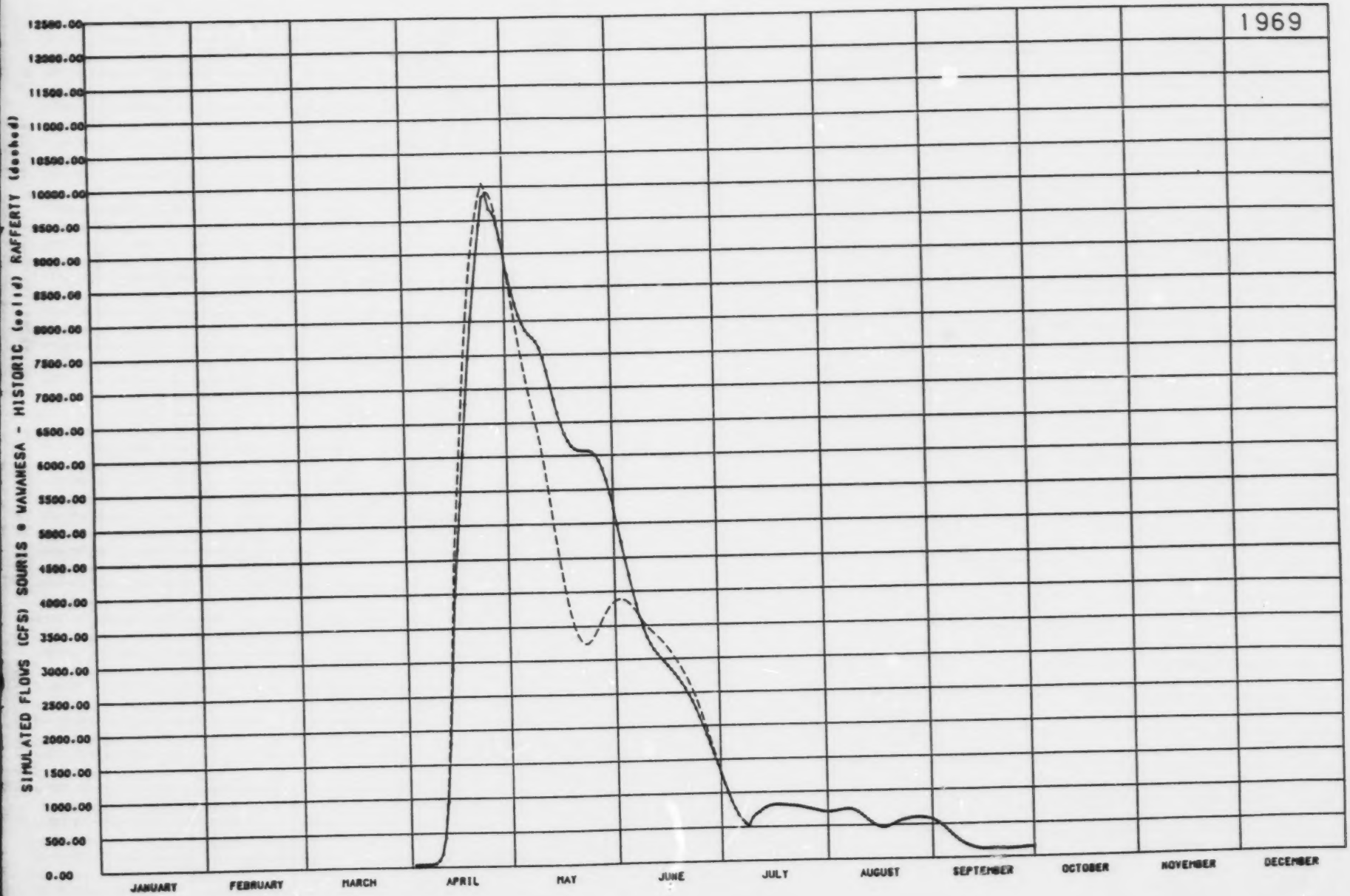
NOVEMBER
DECEMBER


1969
SIMULATED FLOWS (CFS) SOURIS @ WAVANESA - HISTORIC (coiled) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
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6500.00
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JANUARY
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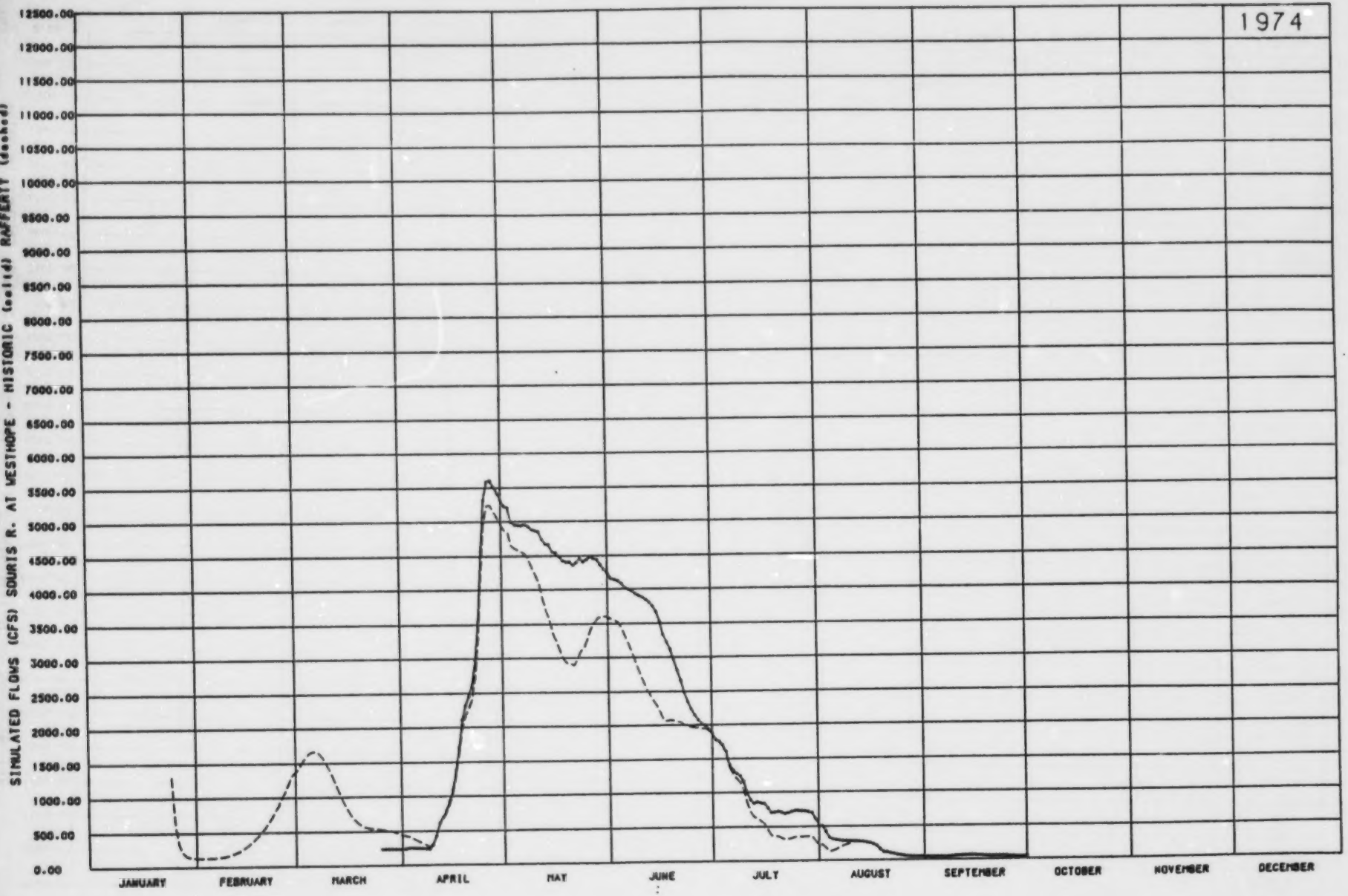
NOVEMBER
DECEMBER


1974
SIMULATED FLOWS (CFS) SOURIS R. AT WESTHOPE - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
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10500.00
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JANUARY
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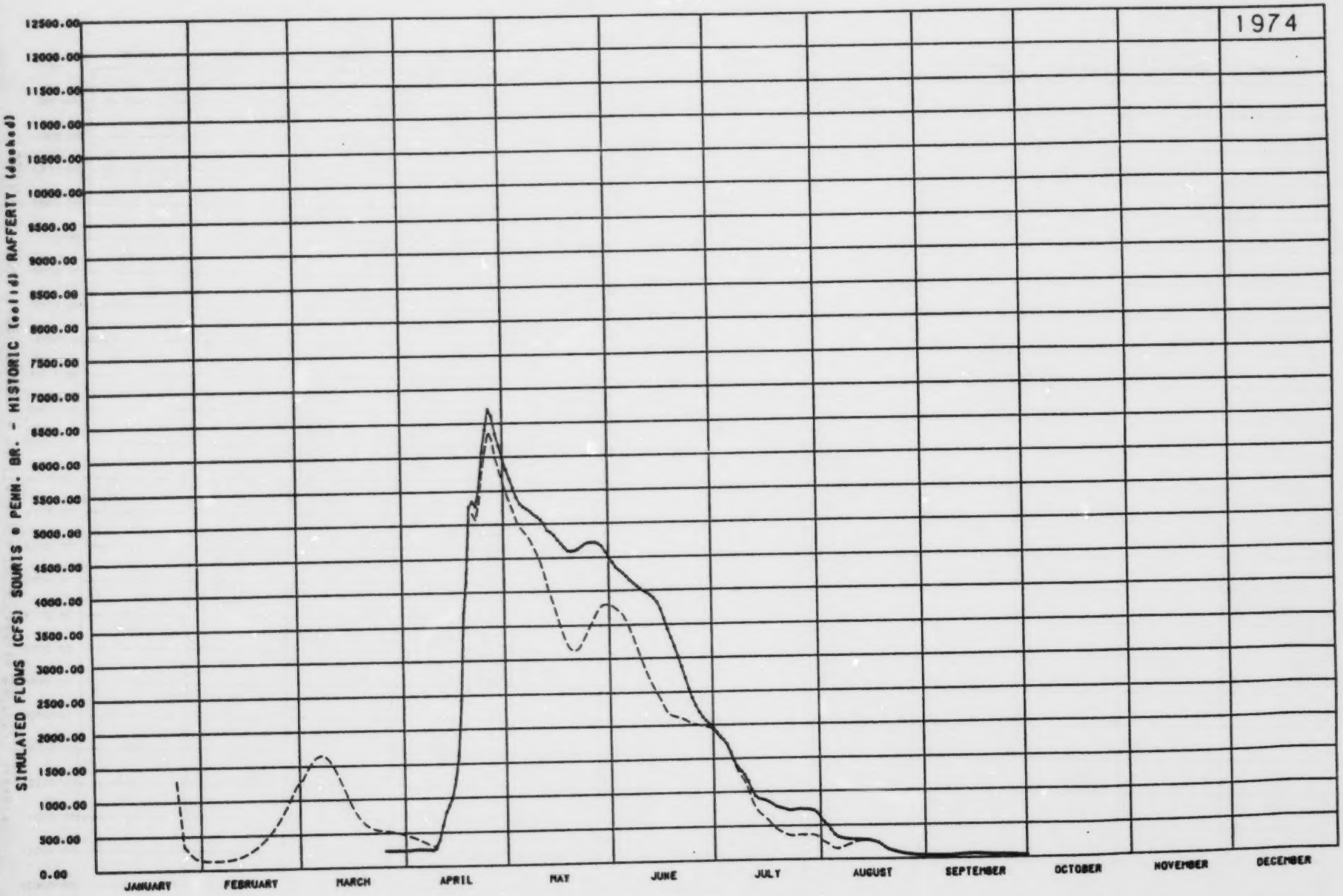
NOVEMBER
DECEMBER


1974
SIMULATED FLOWS (CFS) SOURIS @ PENN. BR. - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
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10500.00
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9500.00
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JANUARY
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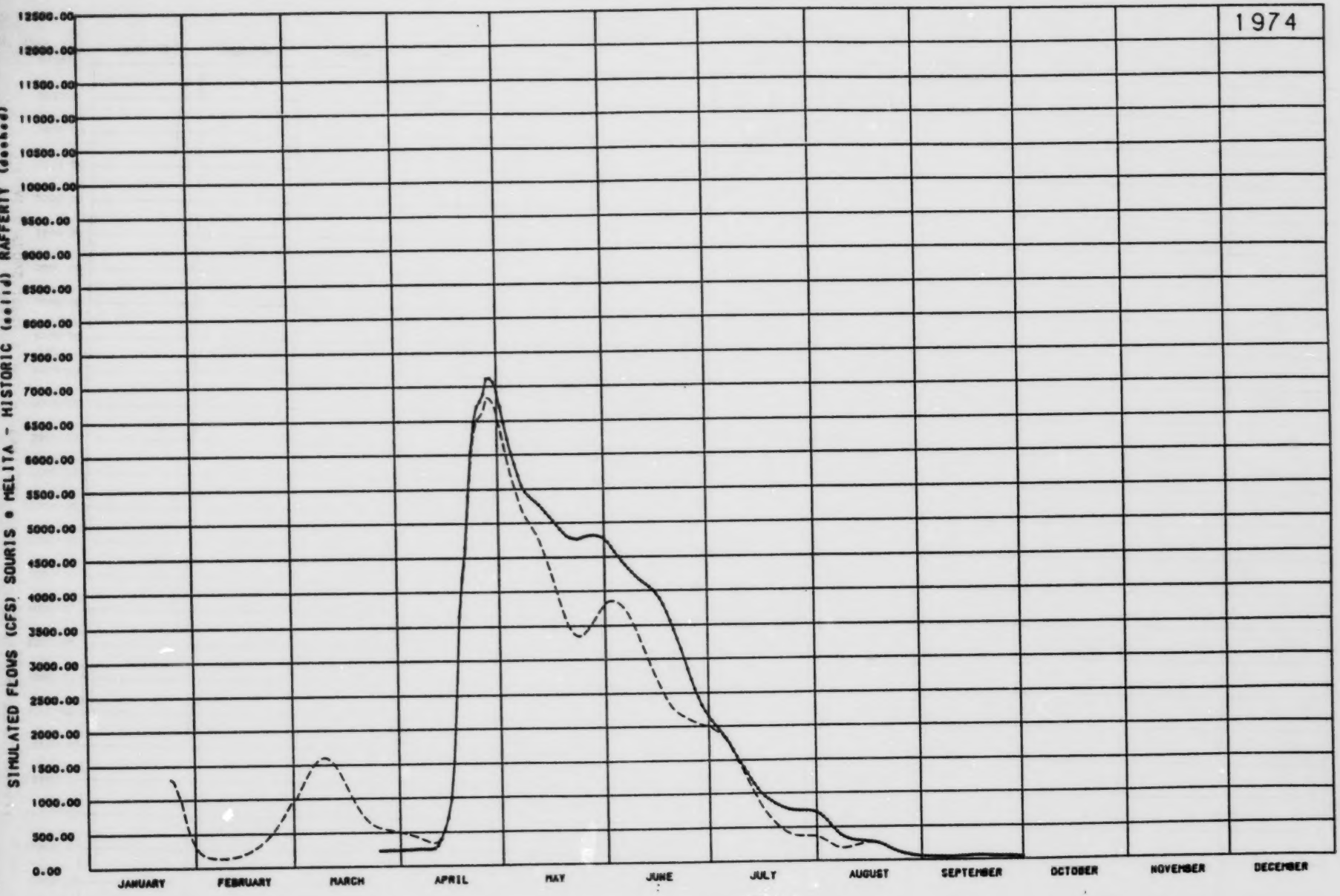
1974
SIMULATED FLOWS (CFS) SOURIS @ MELITA - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
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10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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JANUARY
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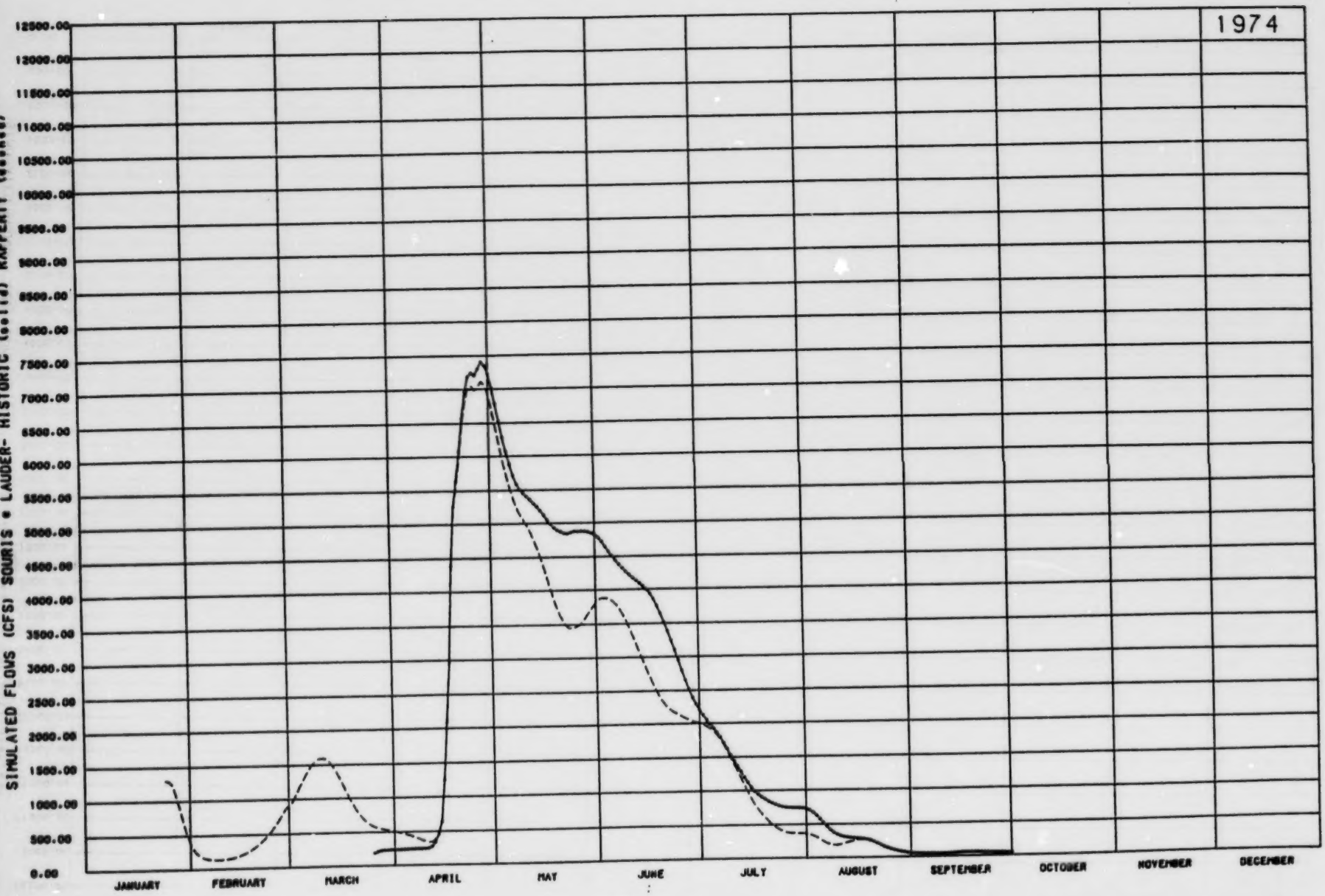
NOVEMBER
DECEMBER


1974
SIMULATED FLOWS (CFS) SOURIS • LAUDER- HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
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10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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JANUARY
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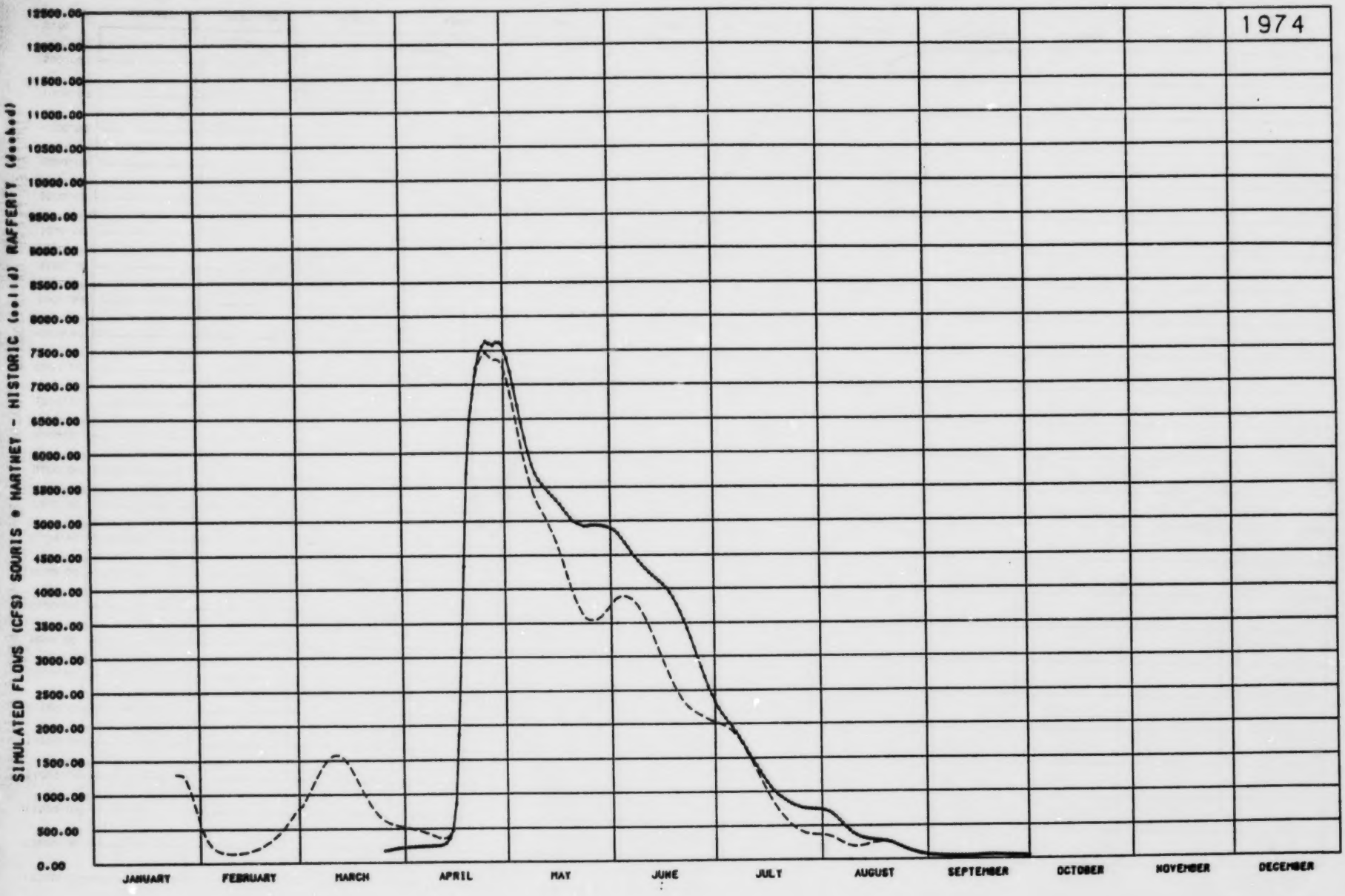
1974
SIMULATED FLOWS (CFS) SOURIS @ HARTNEY - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
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10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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JANUARY
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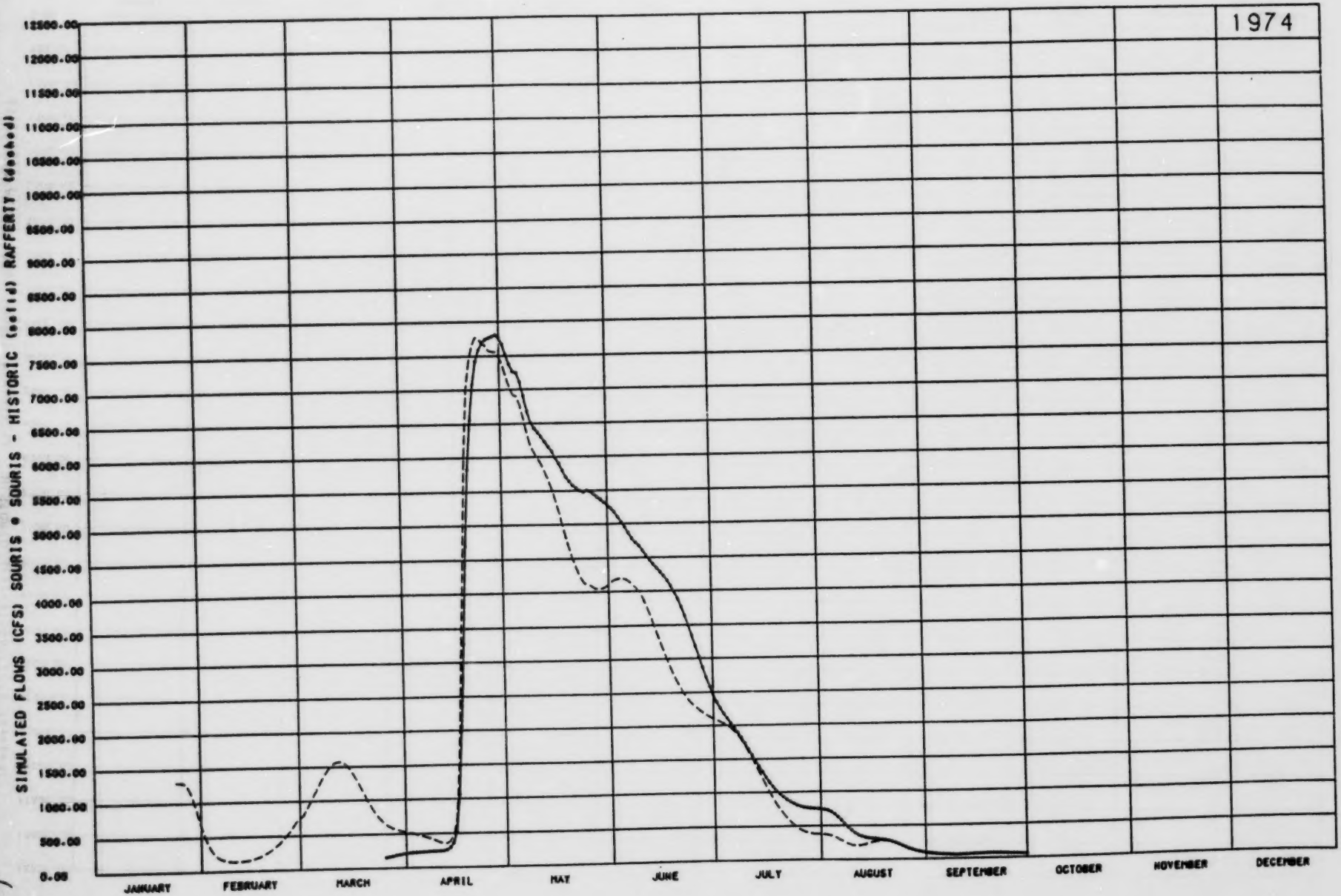
OCTOBER
NOVEMBER
DECEMBER


1974
SIMULATED FLOWS (CFS) SOURIS @ SOURIS - HISTORIC (solid) RAFFERTY (dashed)
12500.00
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10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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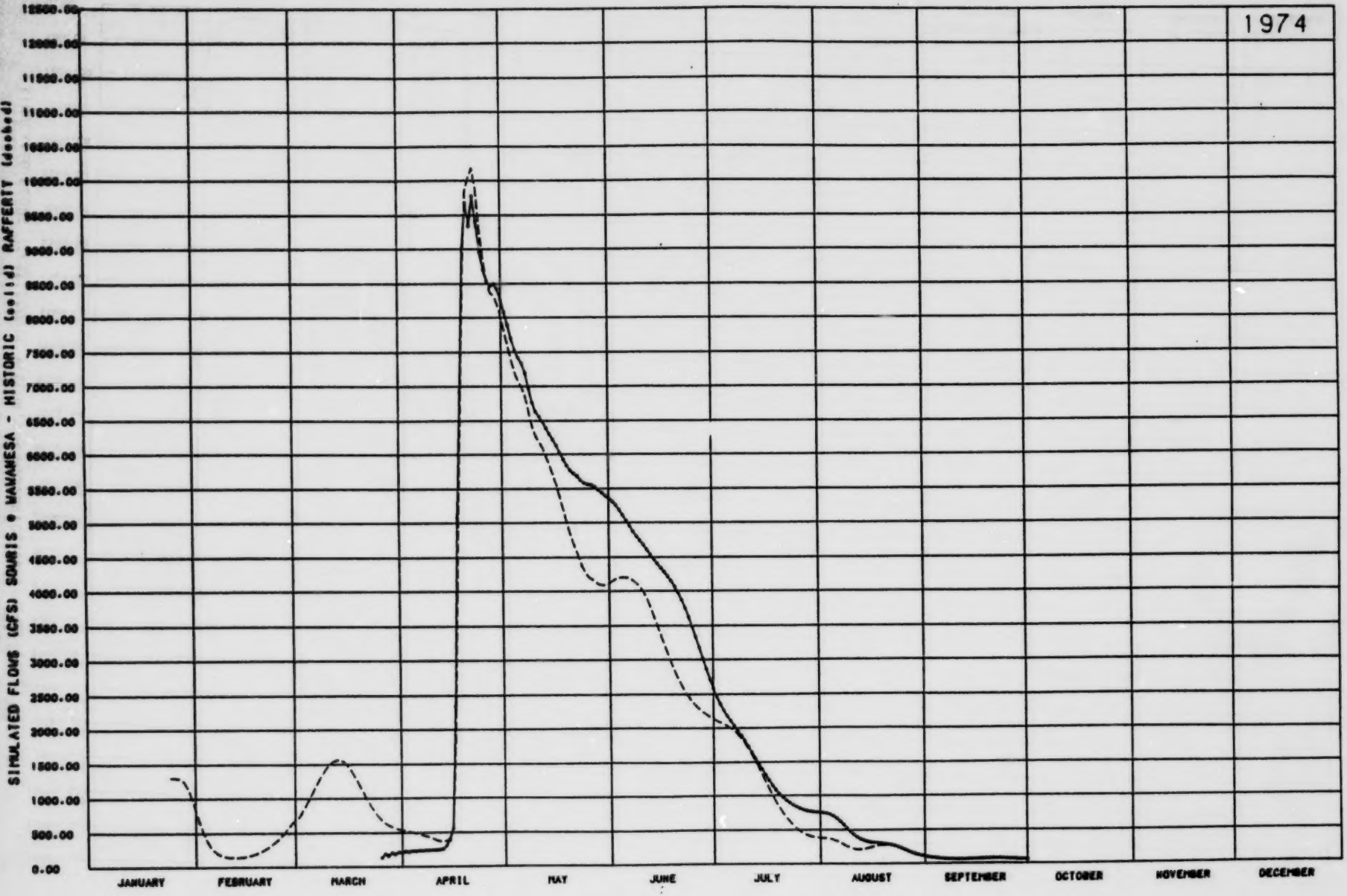
NOVEMBER
DECEMBER


1974
SIMULATED FLOWS (CFS) SOURIS @ WAWANESA - HISTORIC (called) RAFFERTY (doubled)
12500.00
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JANUARY
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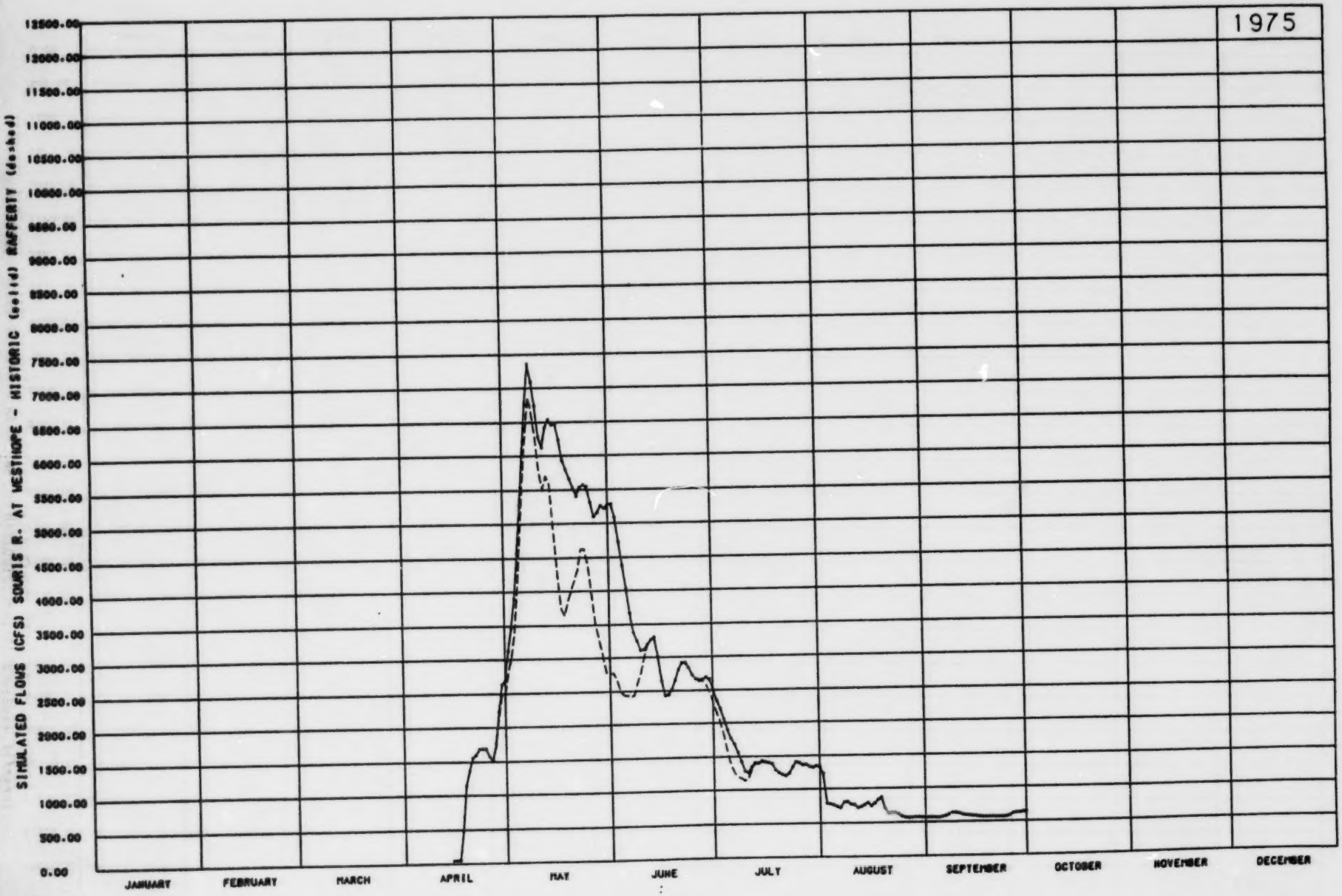
NOVEMBER
DECEMBER


1975
SIMULATED FLOWS (CFS) SOURIS R. AT WESTHOPE - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
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JANUARY
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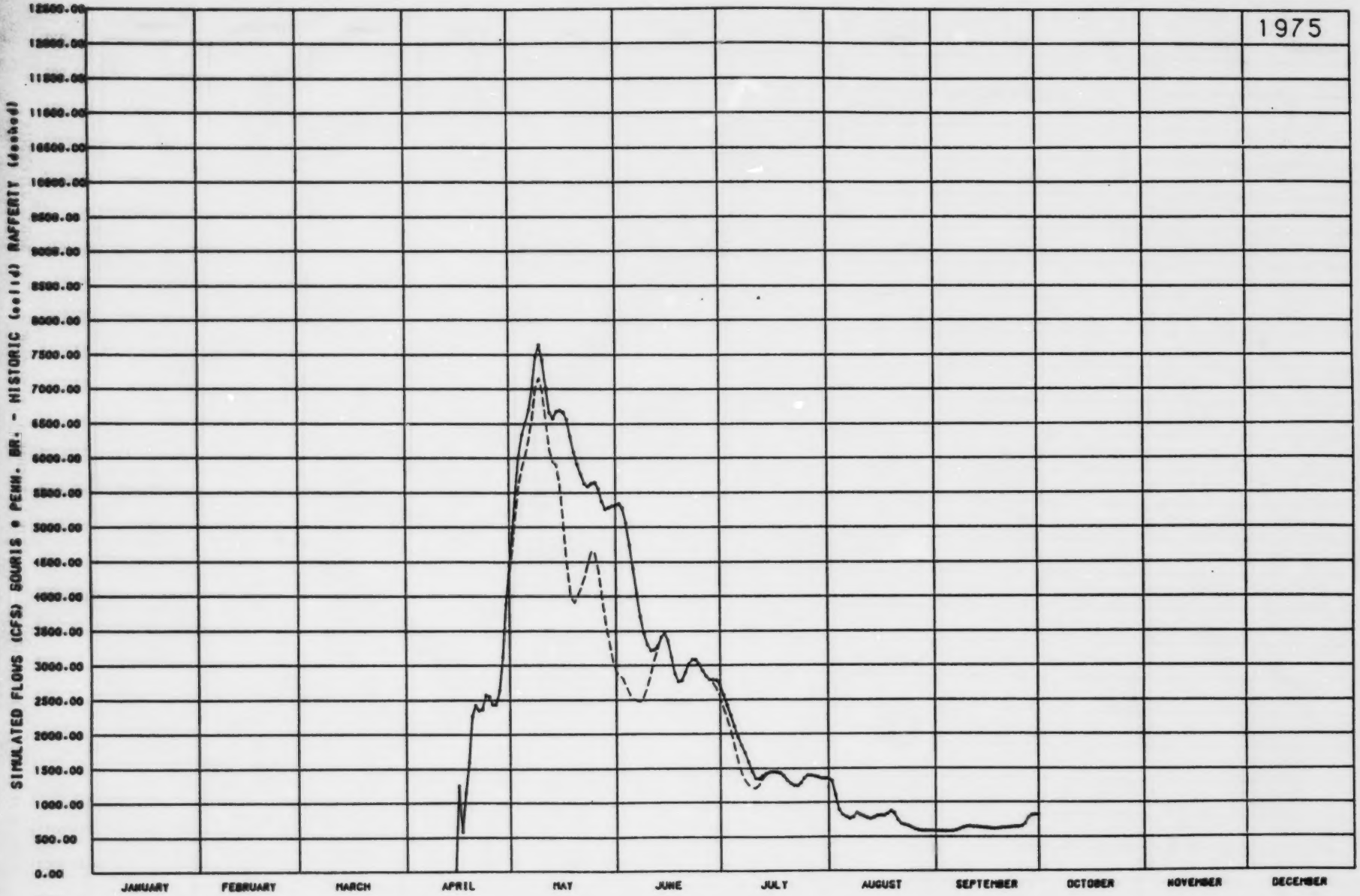
1975
SIMULATED FLOWS (CFS) BOURIS • PENN. BR. - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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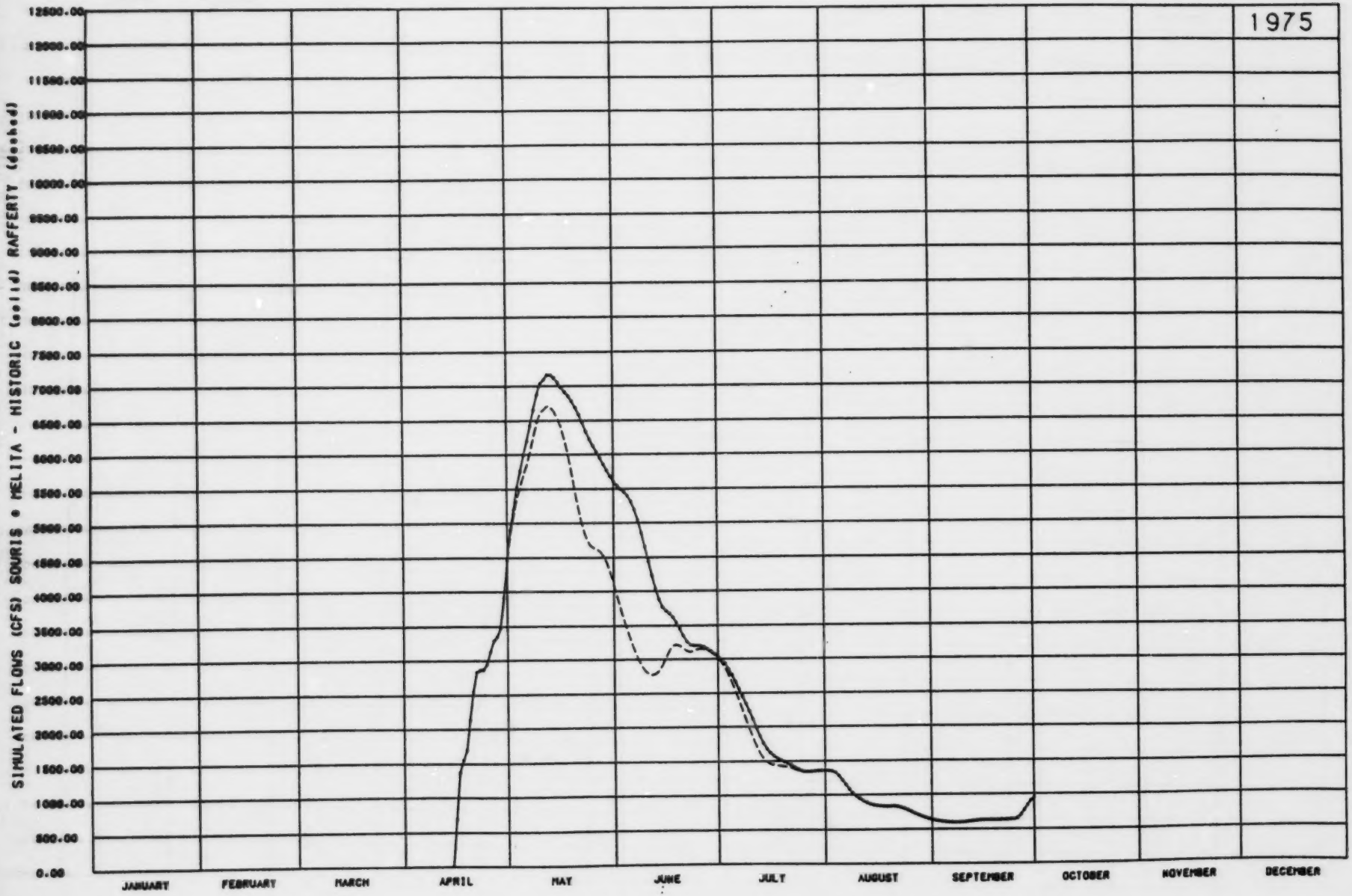
1975
SIMULATED FLOWS (CFS) SOURIS @ MELITA - HISTORIC (solid) RAFFERTY (dashed)
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9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
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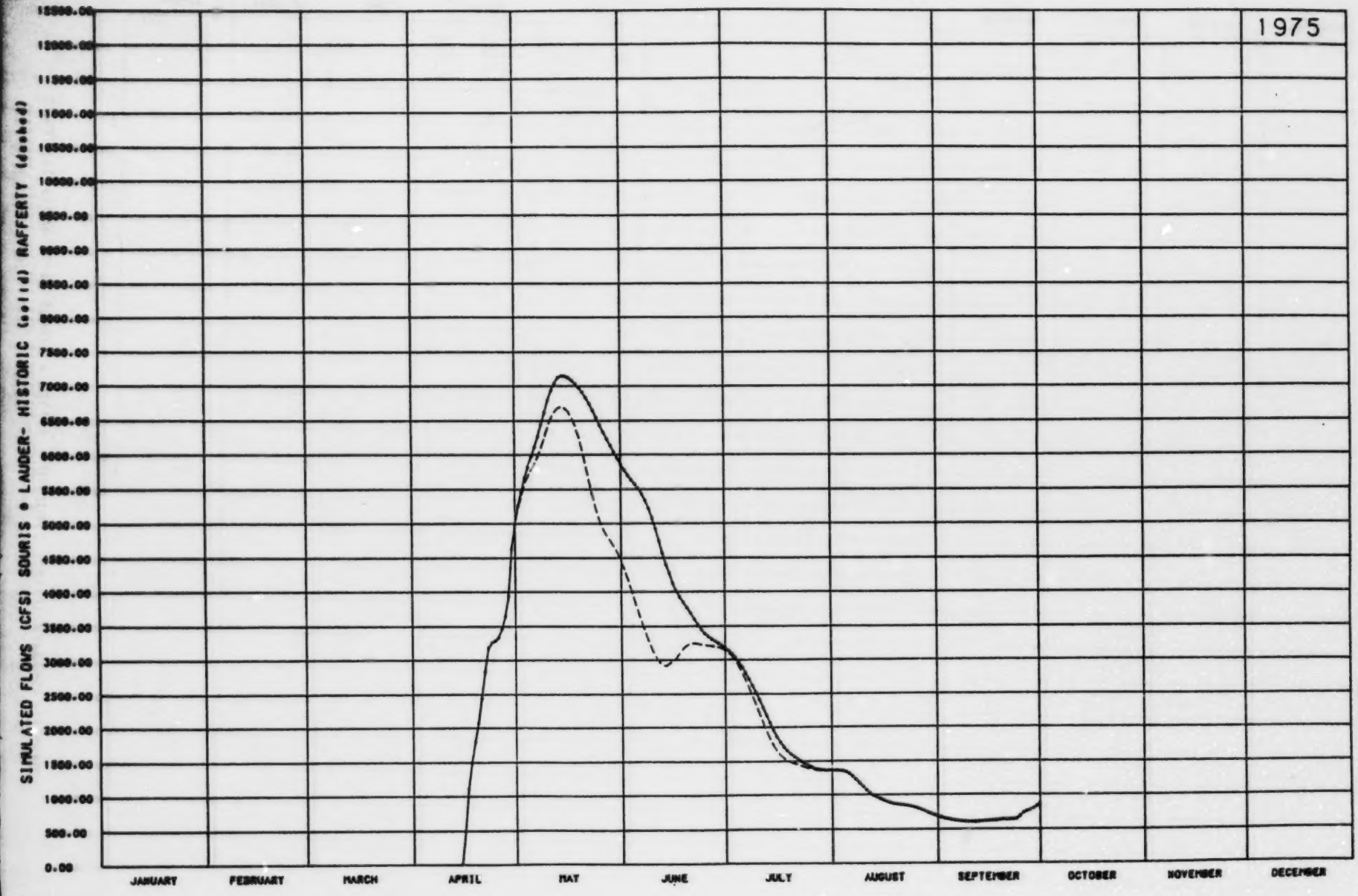
DECEMBER


1975
SIMULATED FLOWS (CFS) SOURIS @ LAUDER- HISTORIC (solid) RAFFERTY (dashed)
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11000.00
10500.00
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9000.00
8500.00
8000.00
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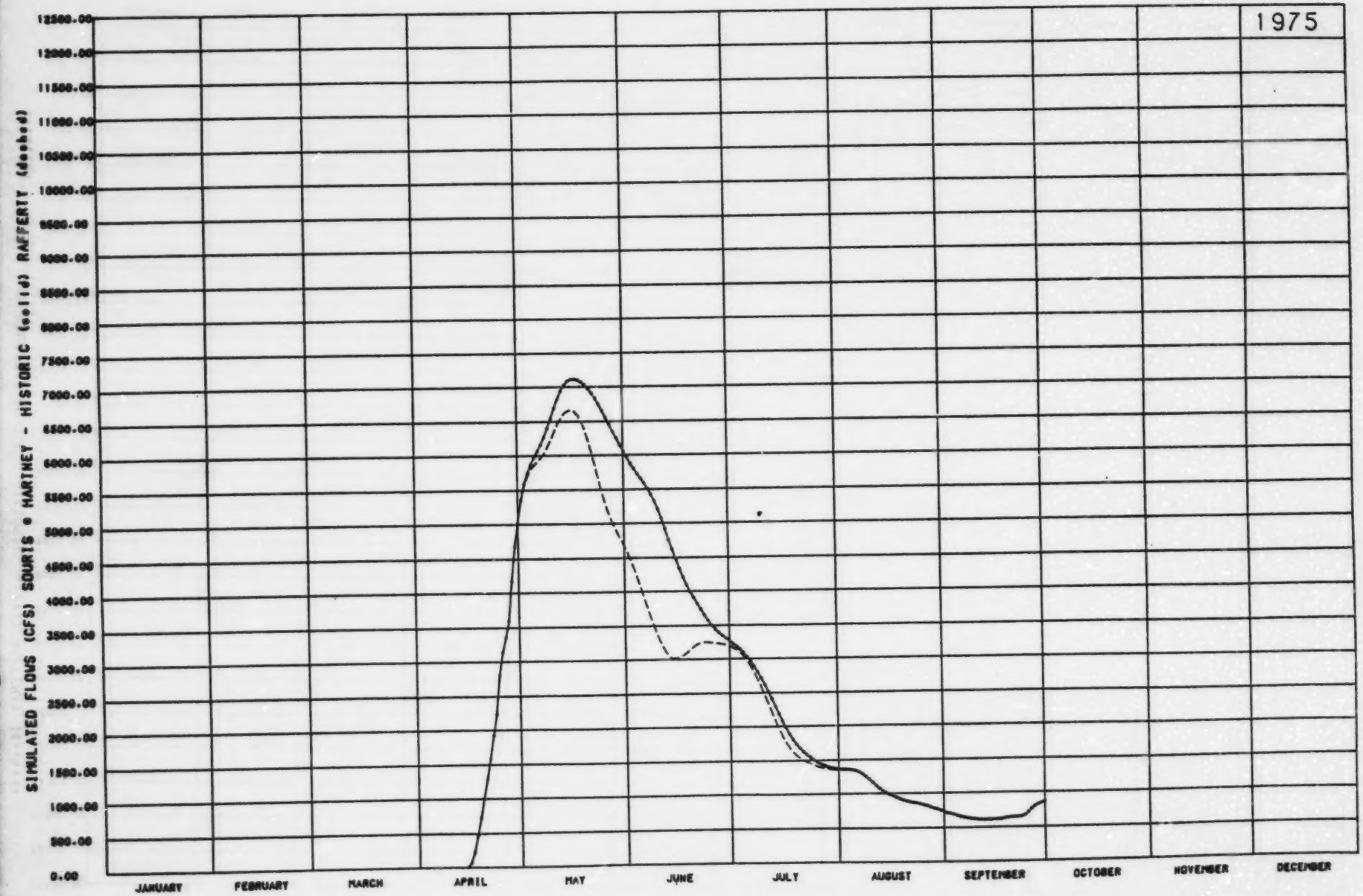
1975
SIMULATED FLOWS (CFS) SOURIS • HARTNEY - HISTORIC (solid) RAFFERTY (dashed)
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12000.00
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11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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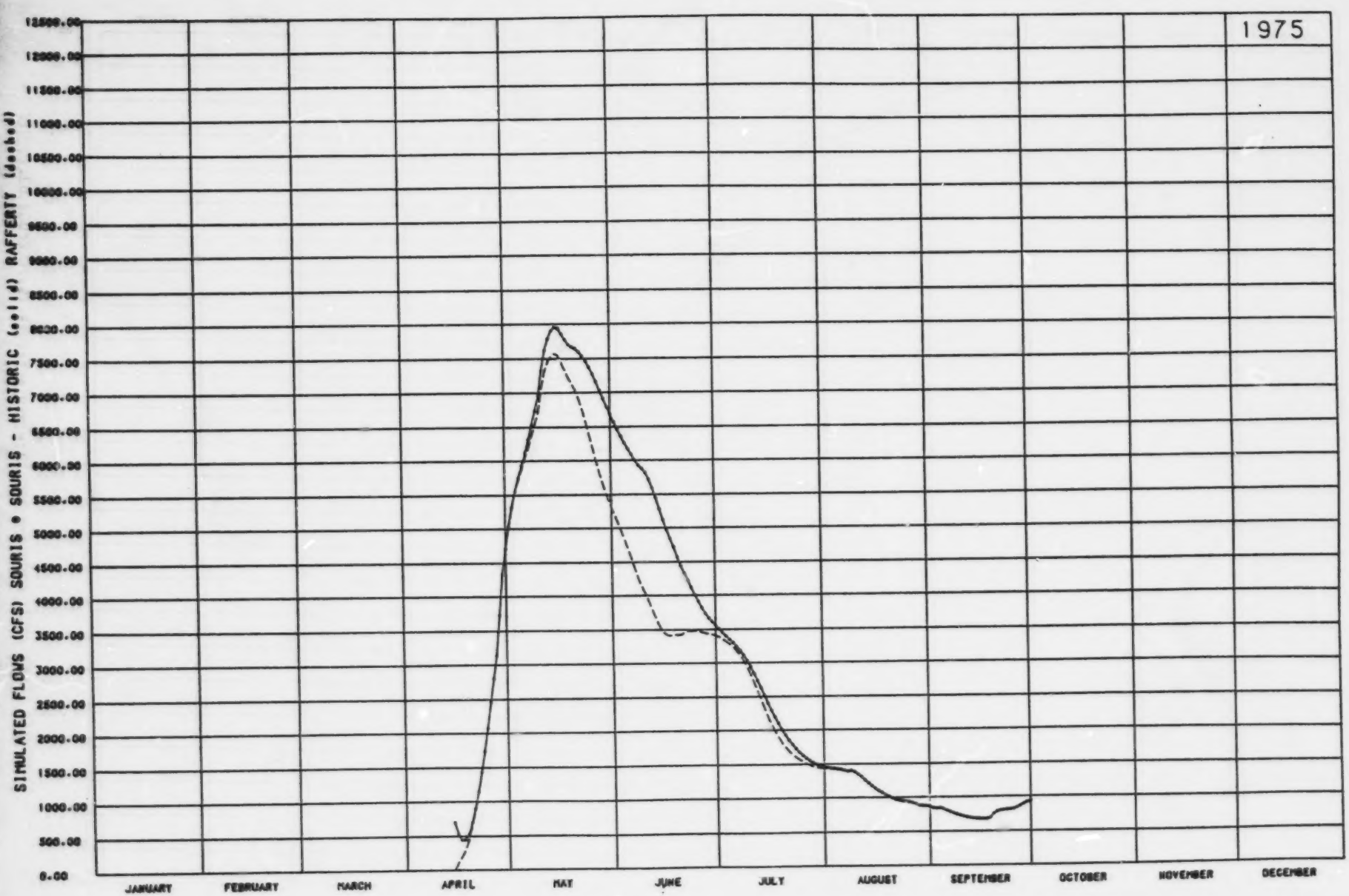
1975
SIMULATED FLOWS (CFS) SOURIS • SOURIS - HISTORIC (adjusted) RAFFERTY (doubled)
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12000.00
11500.00
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10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
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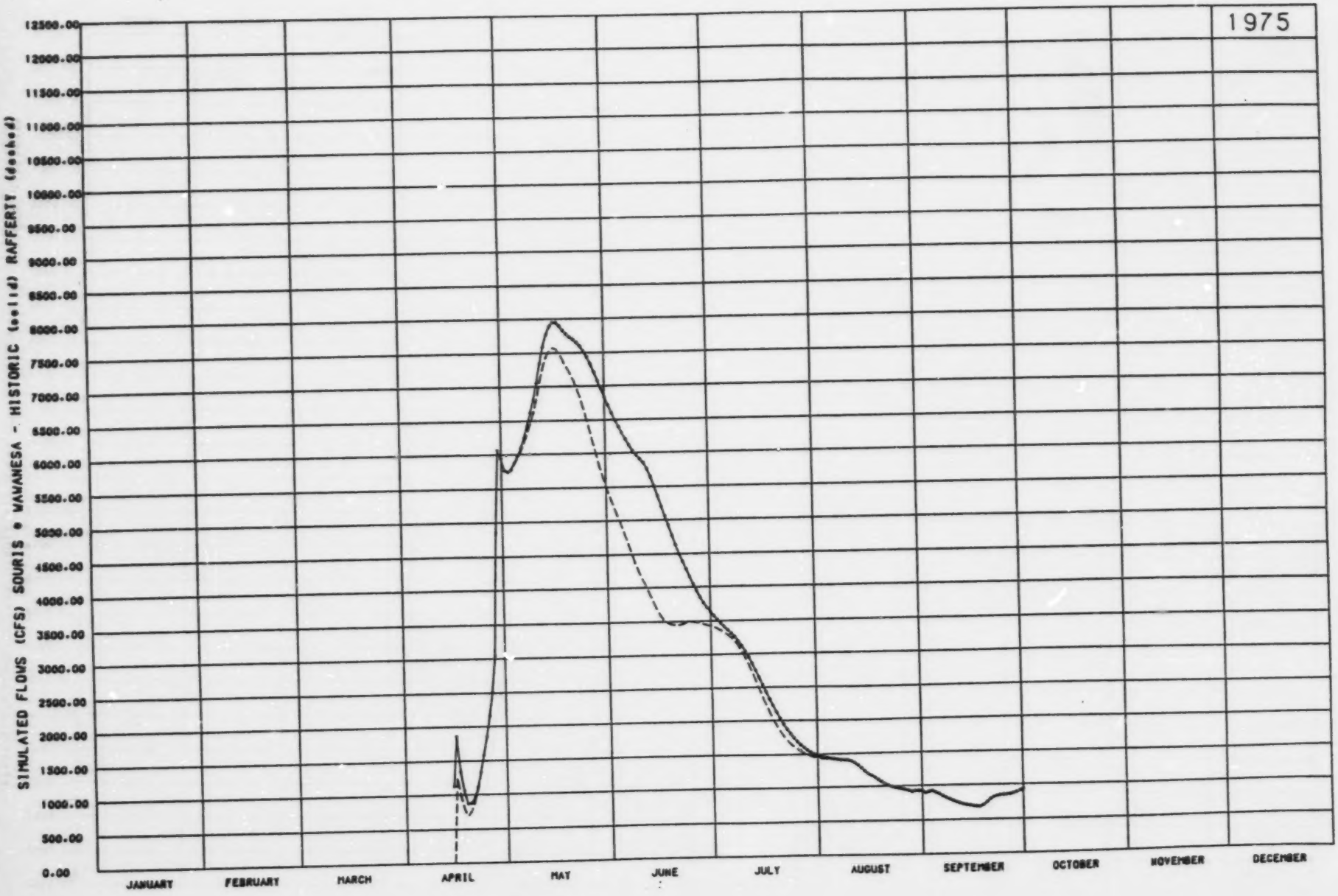
1975
SIMULATED FLOWS (CFS) SOURIS • WAVANESA - HISTORIC (called) RAFFERTY (dashed)
12500.00
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10500.00
10000.00
9500.00
9000.00
8500.00
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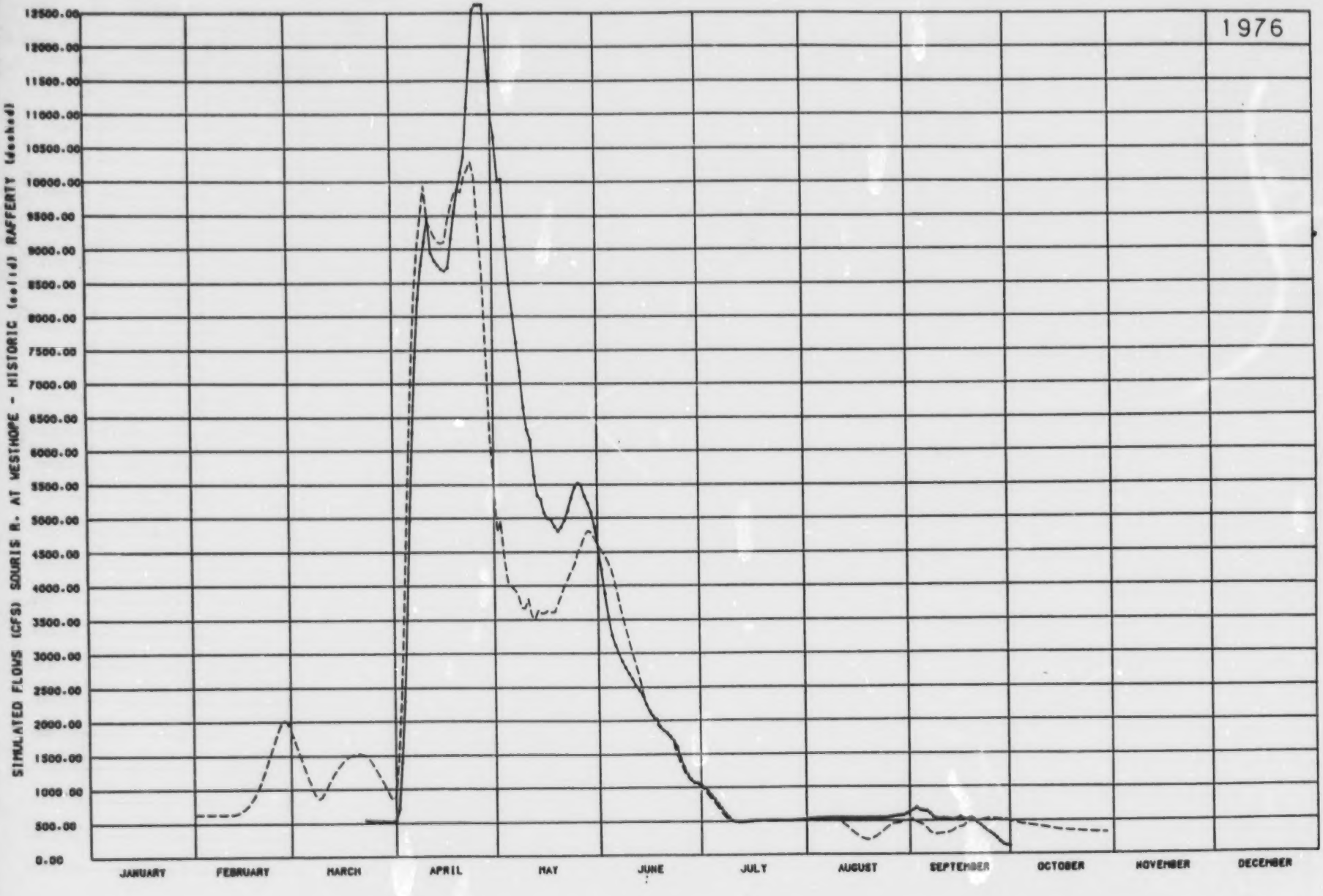
1976
SIMULATED FLOWS (CFS) SOURIS R. AT WESTHOPE - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
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8500.00
8000.00
7500.00
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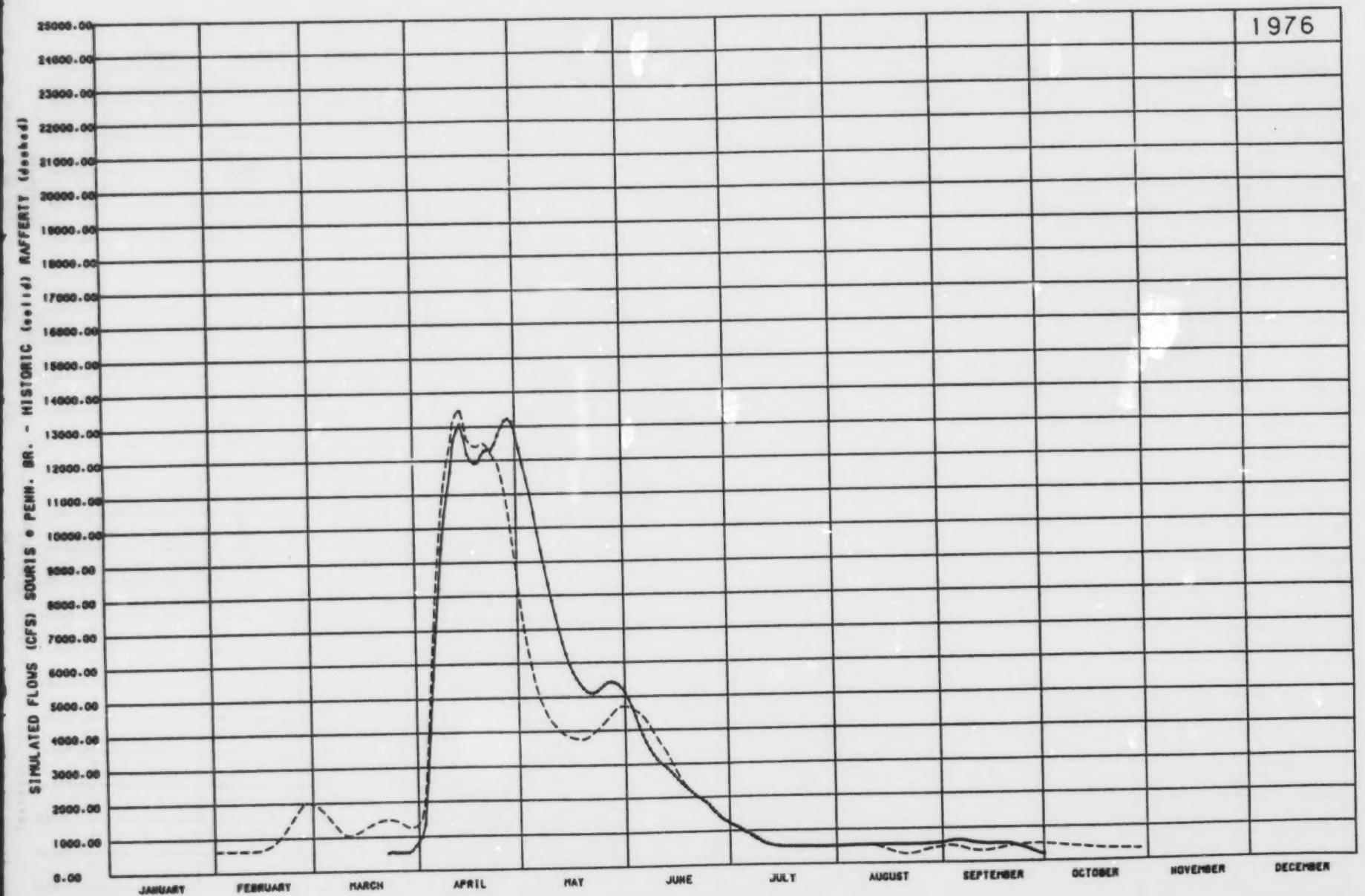
1976
SIMULATED FLOWS (CFS) SOURIS @ PENN. BR. - HISTORIC (solid) RAFFERTY (dashed)
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23000.00
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21000.00
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18000.00
17000.00
16000.00
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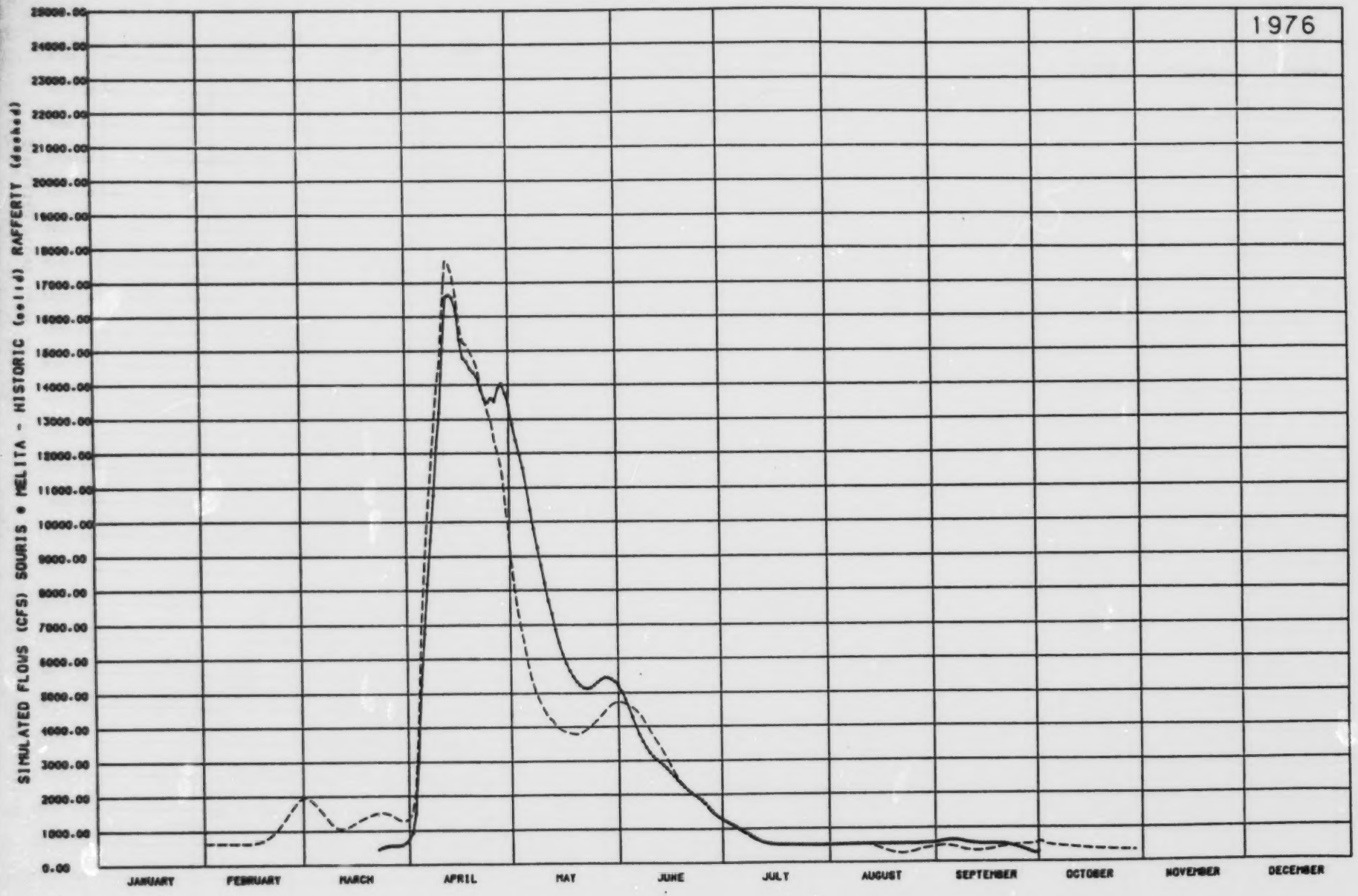
1976
SIMULATED FLOWS (CFS) SOURIS • MELITA - HISTORIC (solid) RAFFERTY (dashed)
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18000.00
17000.00
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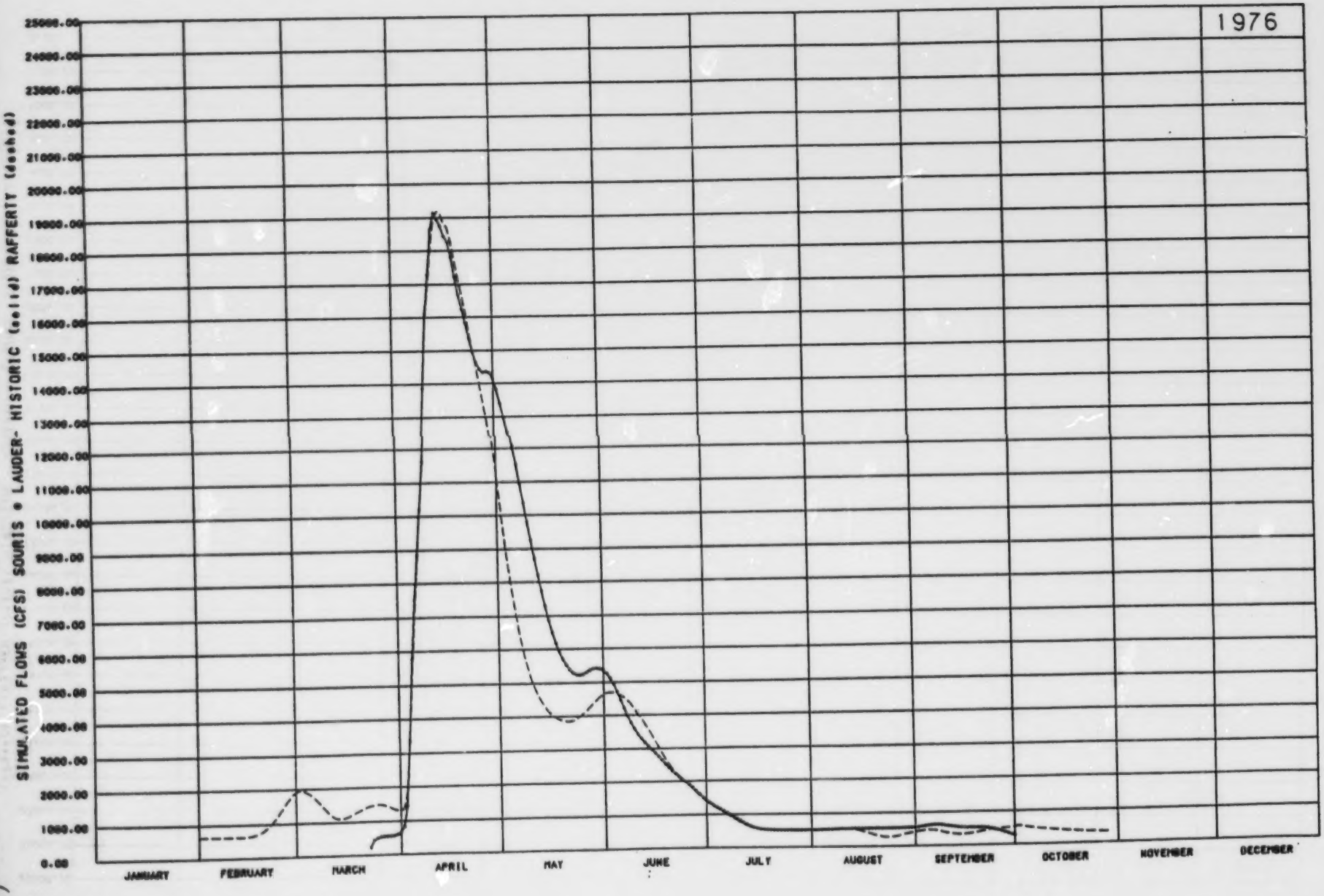
1976
SIMULATED FLOWS (CFS) SOURIS @ LAUDER- HISTORIC (solid) RAFFERTY (dashed)
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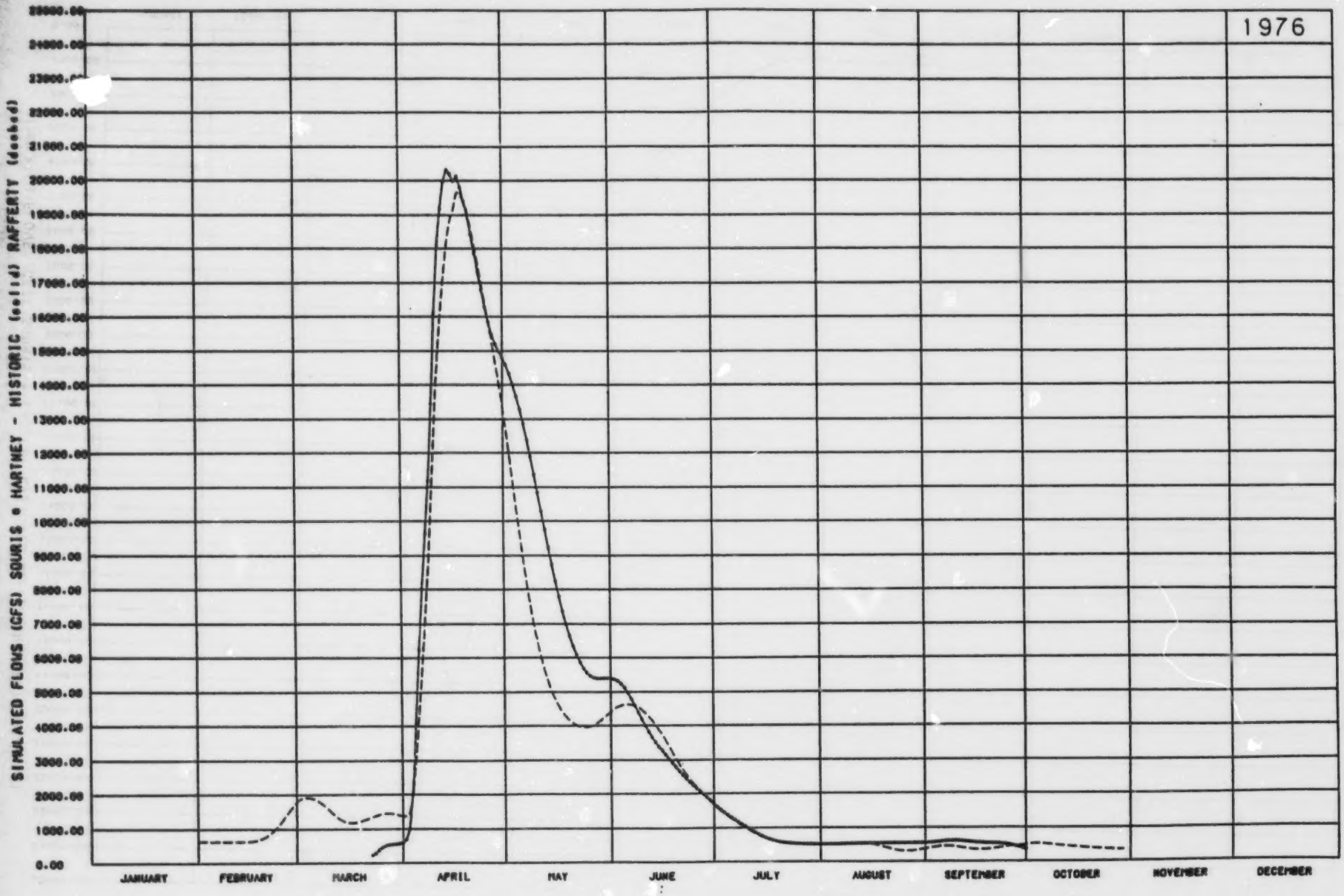
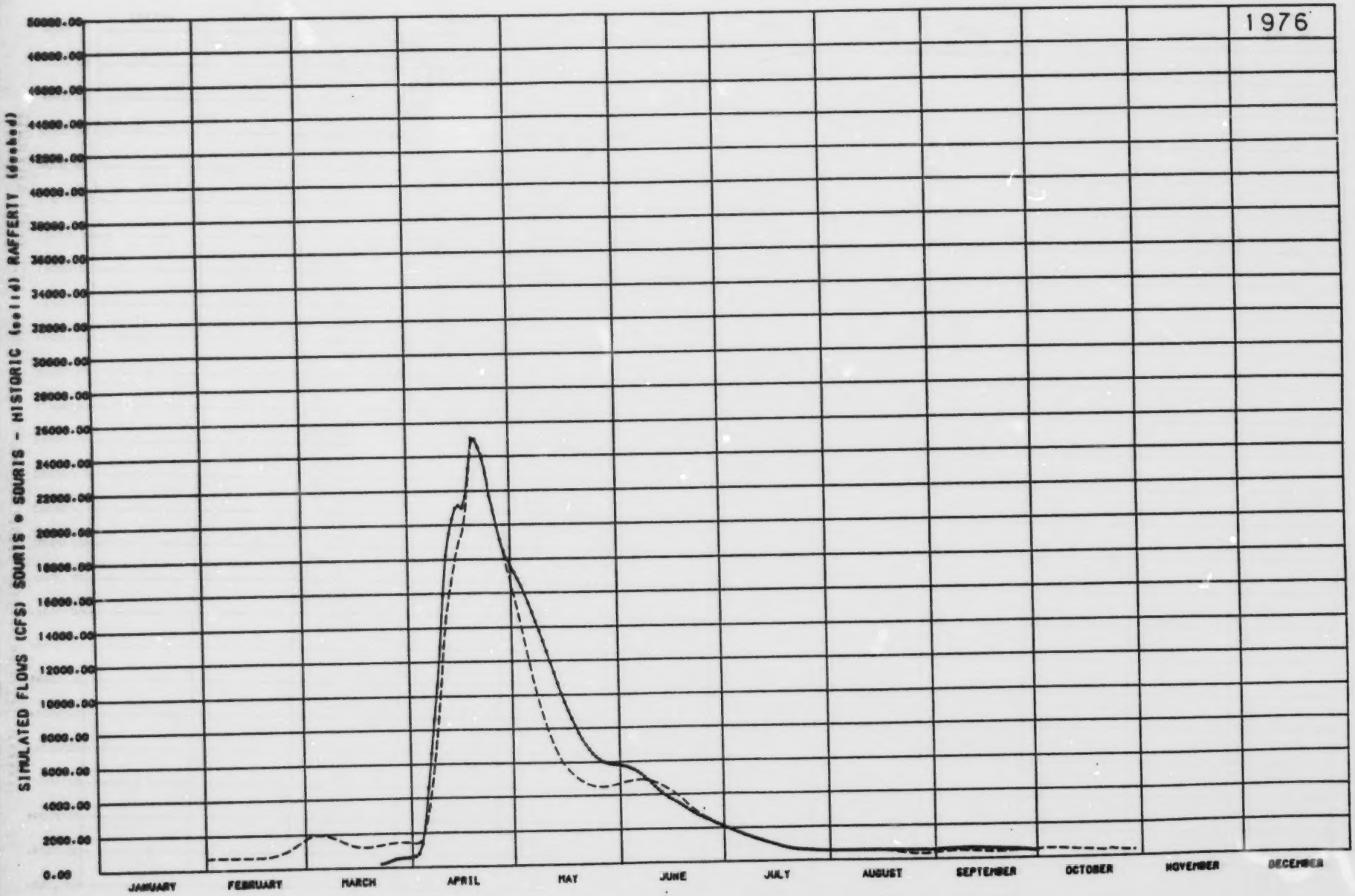
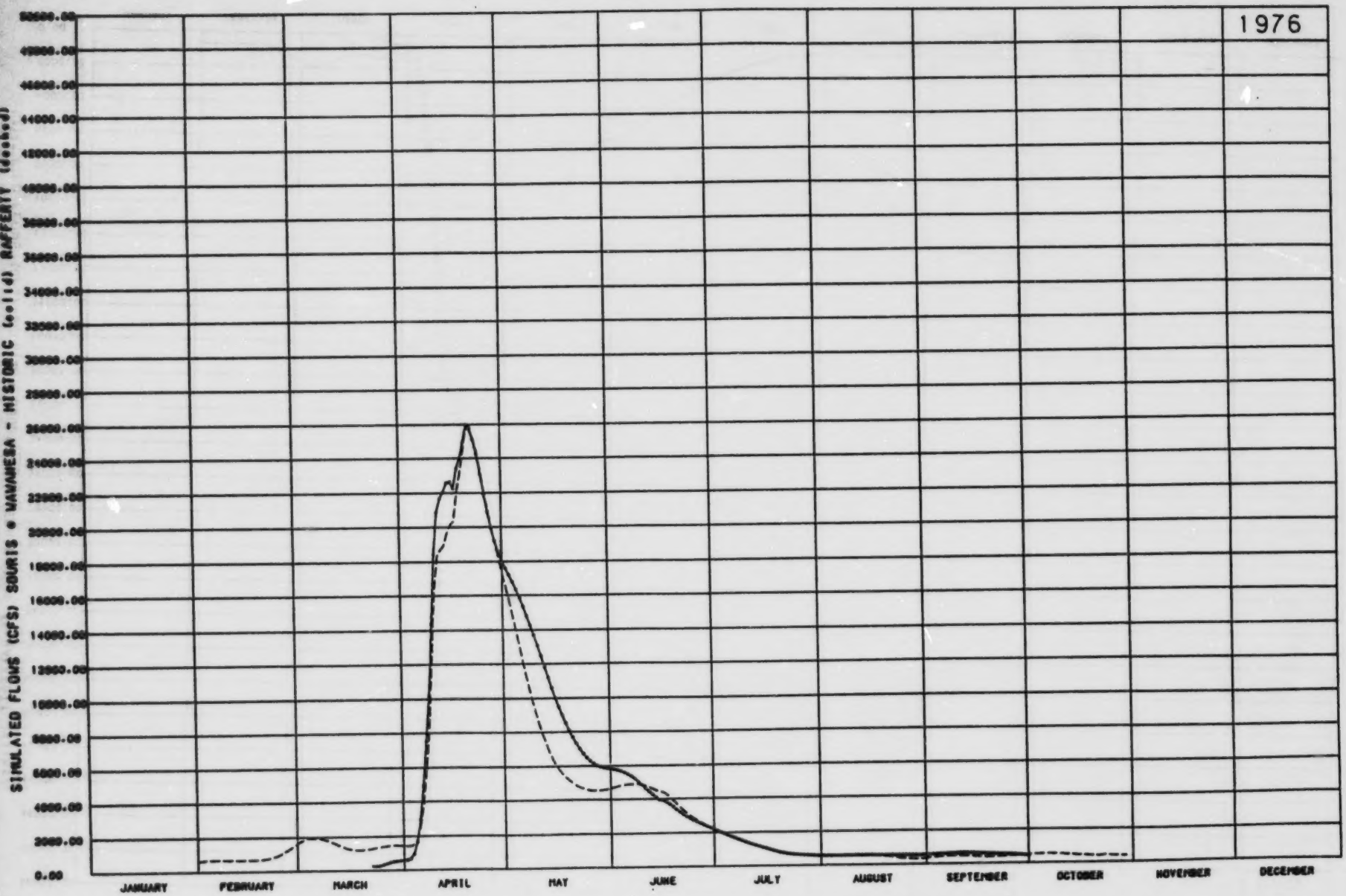
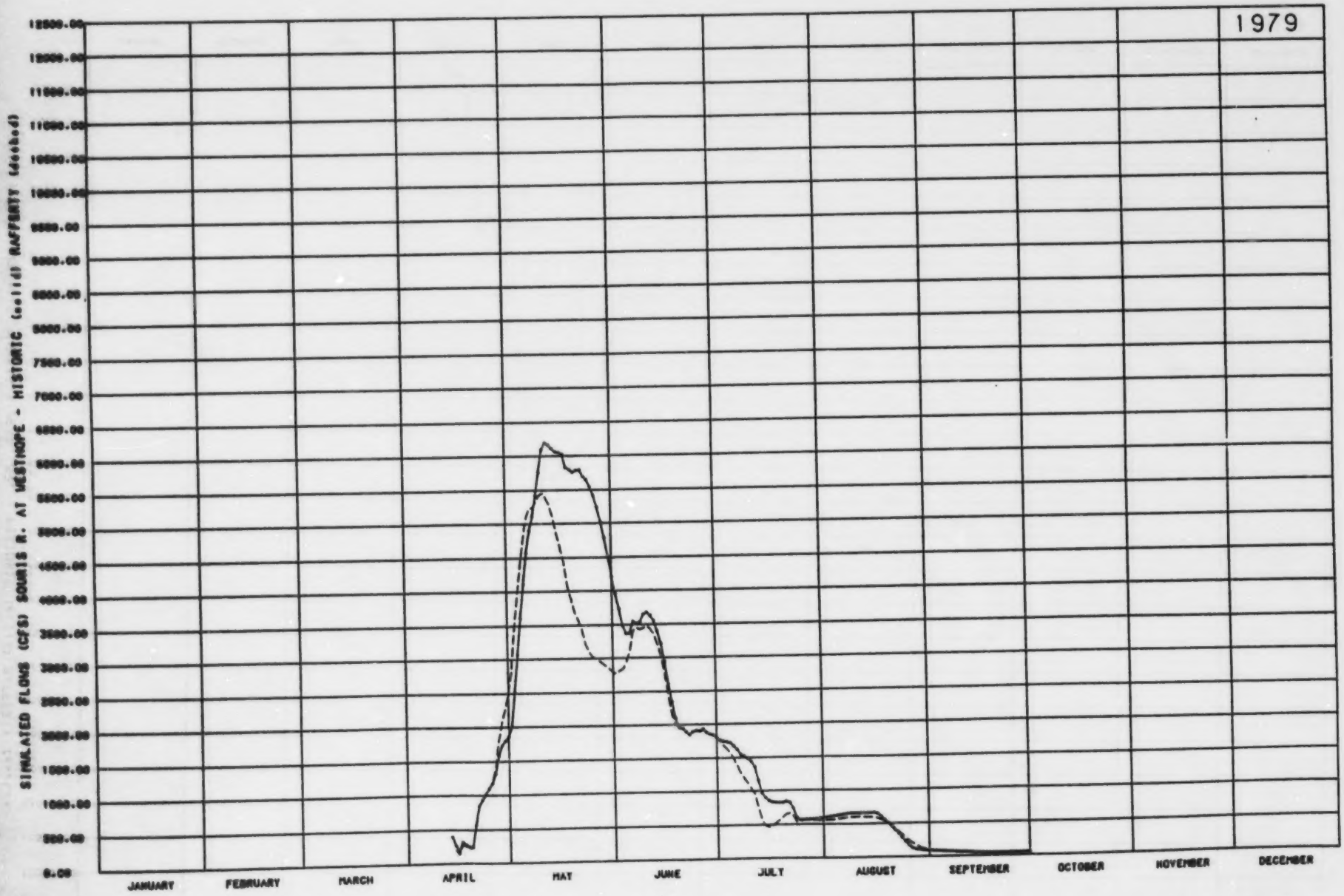
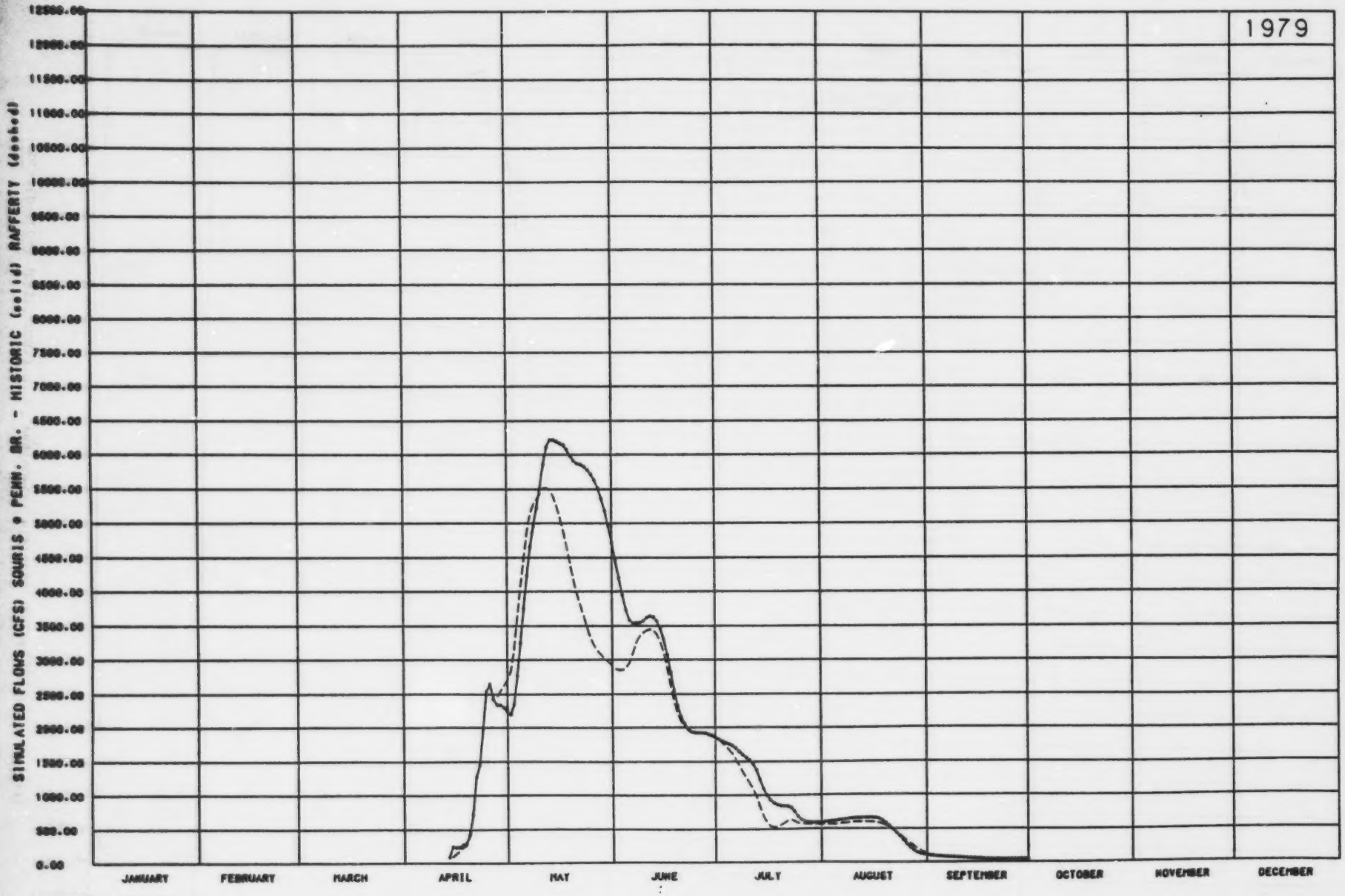
NOVEMBER
DECEMBER


1976
SIMULATED FLOWS (CFS) SOURIS @ HARTNEY - HISTORIC (called) RAFFERTY (decked)
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1976
SIMULATED FLOWS (CFS) SOURIS • SOURIS - HISTORIC (solid) RAFFERTY (dashed)
50000.00
48000.00
46000.00
44000.00
42000.00
40000.00
38000.00
36000.00
34000.00
32000.00
30000.00
28000.00
26000.00
24000.00
22000.00
20000.00
18000.00
16000.00
14000.00
12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1976
SIMULATED FLOWS (CFS) SOURIS @ MAWANESA - HISTORIC (solid) RAFFERTY (dashed)
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1979
SIMULATED FLOWS (CFS) SOURIS R. AT WESTHOPE - HISTORIC (solid) RAFFERTY (dashed)
12500.00
11000.00
10000.00
9000.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1979
SIMULATED FLOWS (CFS) SOURIS @ PENN. BR. - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
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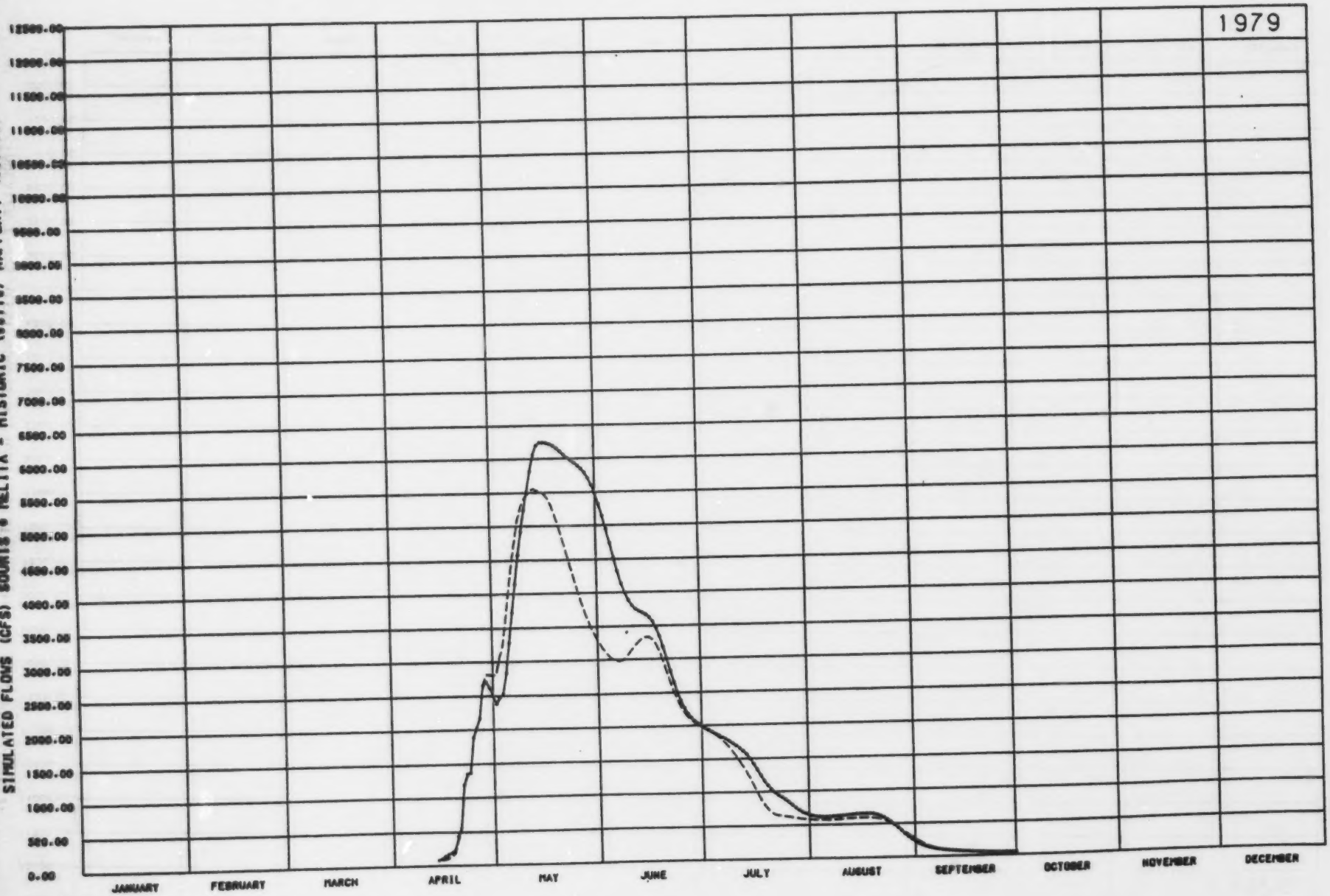
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


1979
SIMULATED FLOWS (CFS) SOURIS @ MELITA - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
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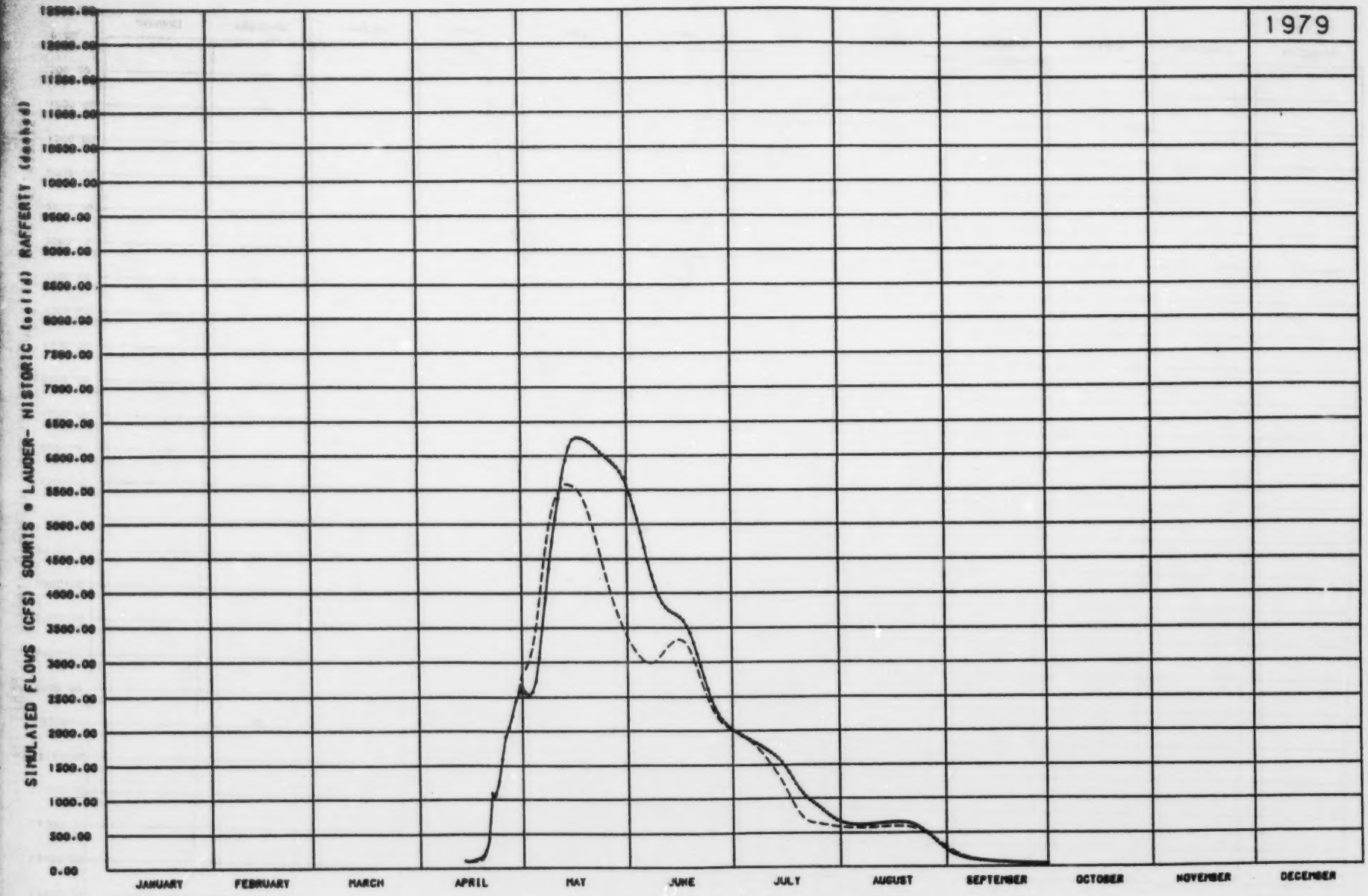
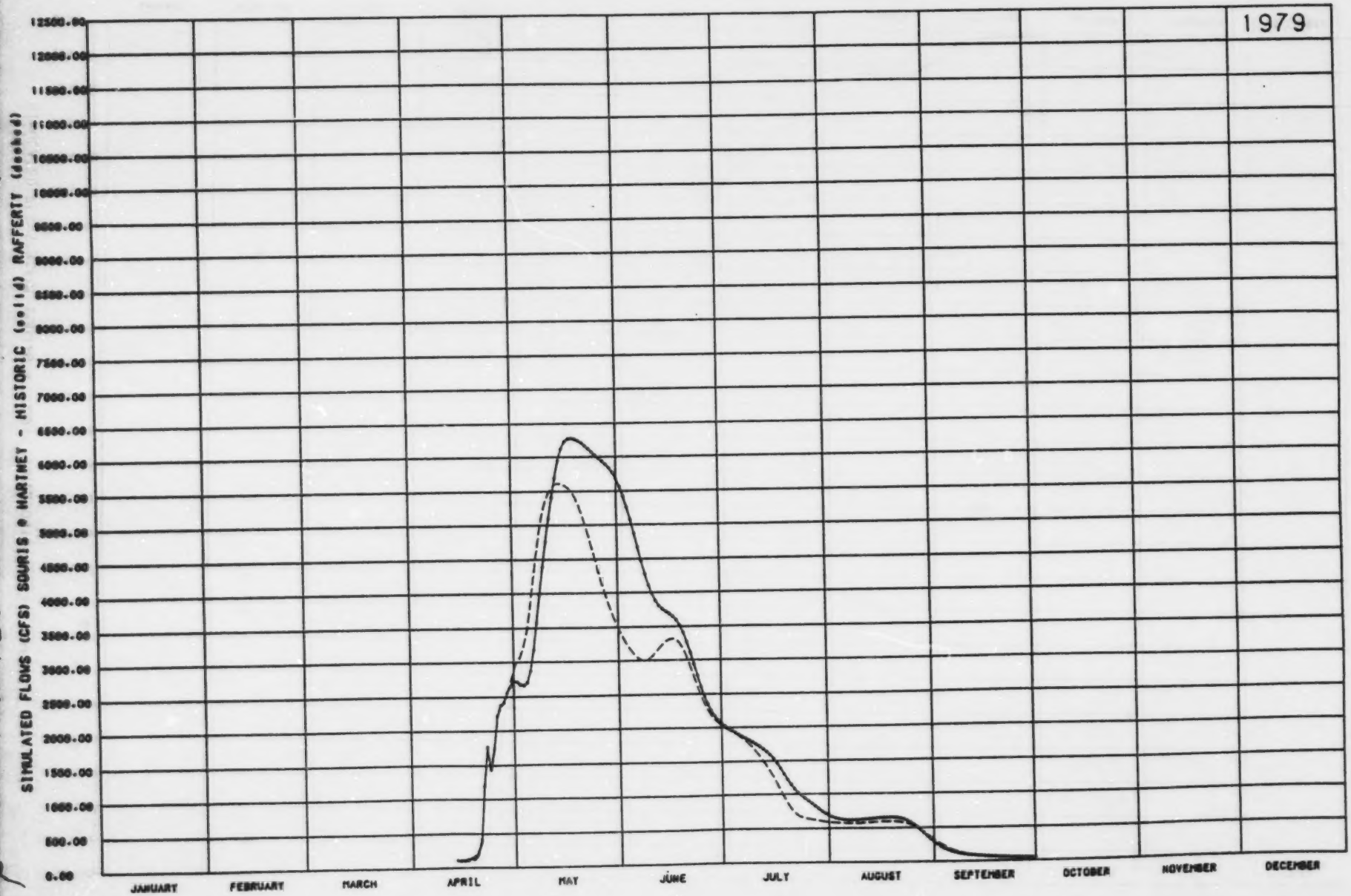
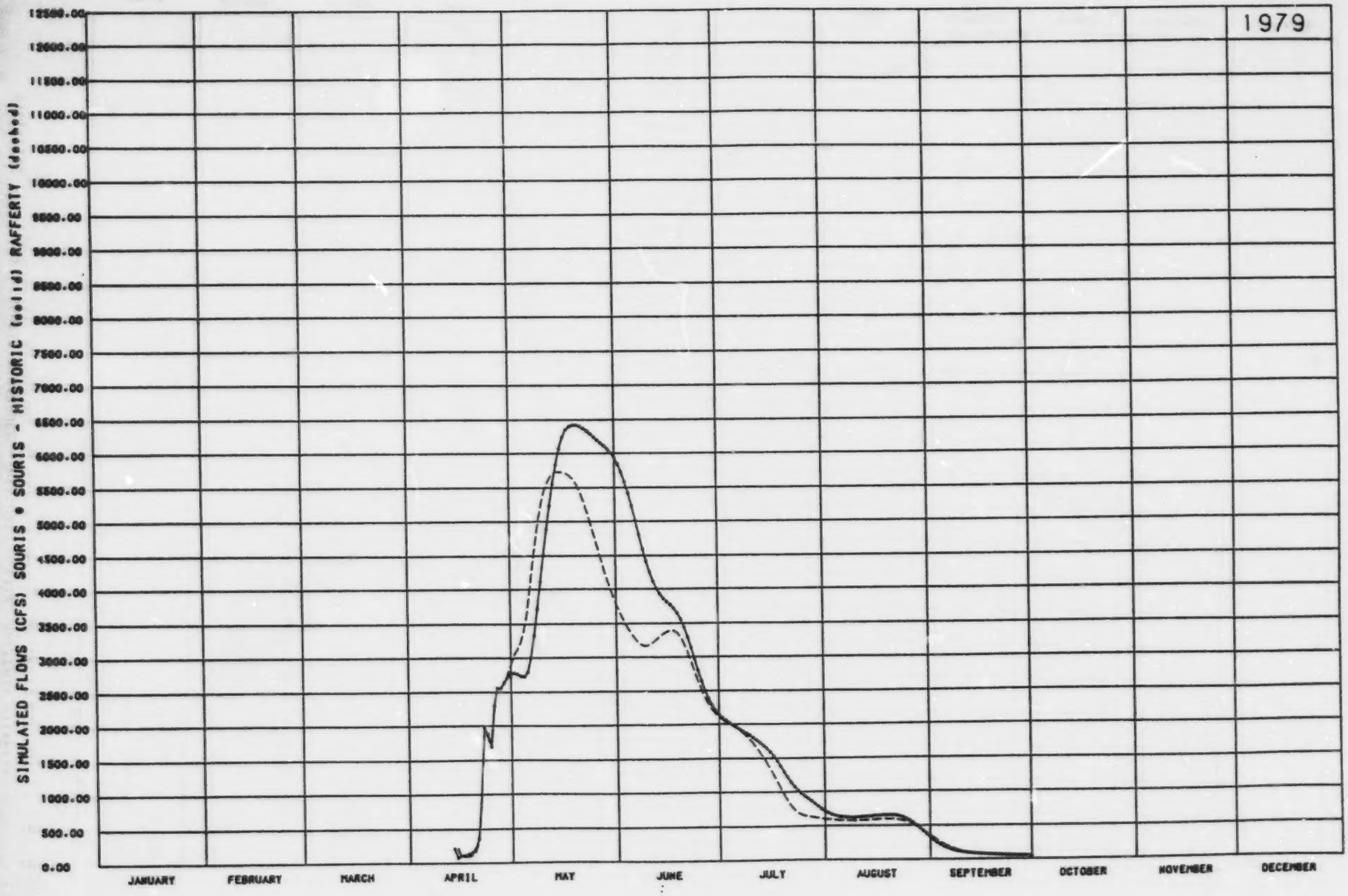
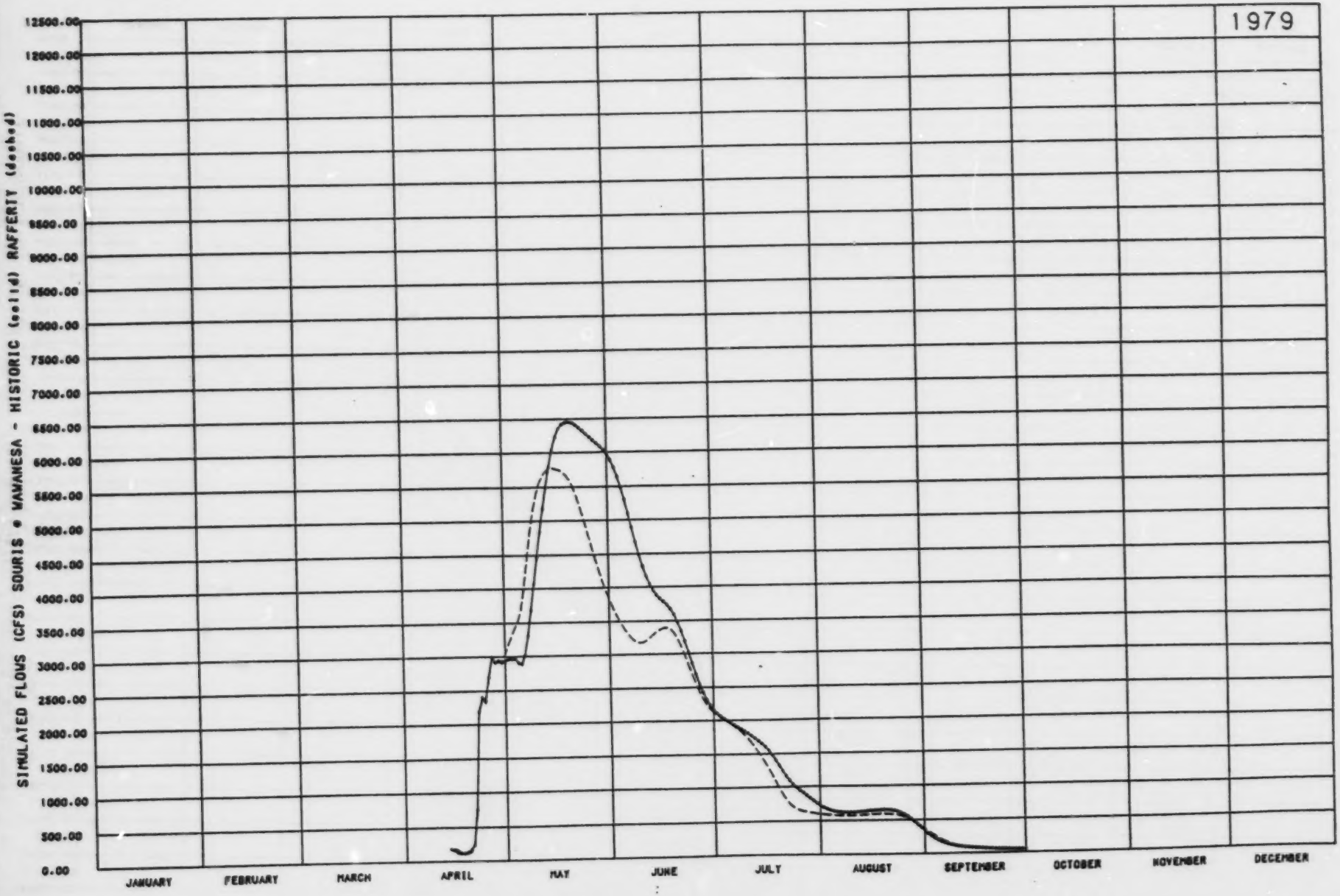
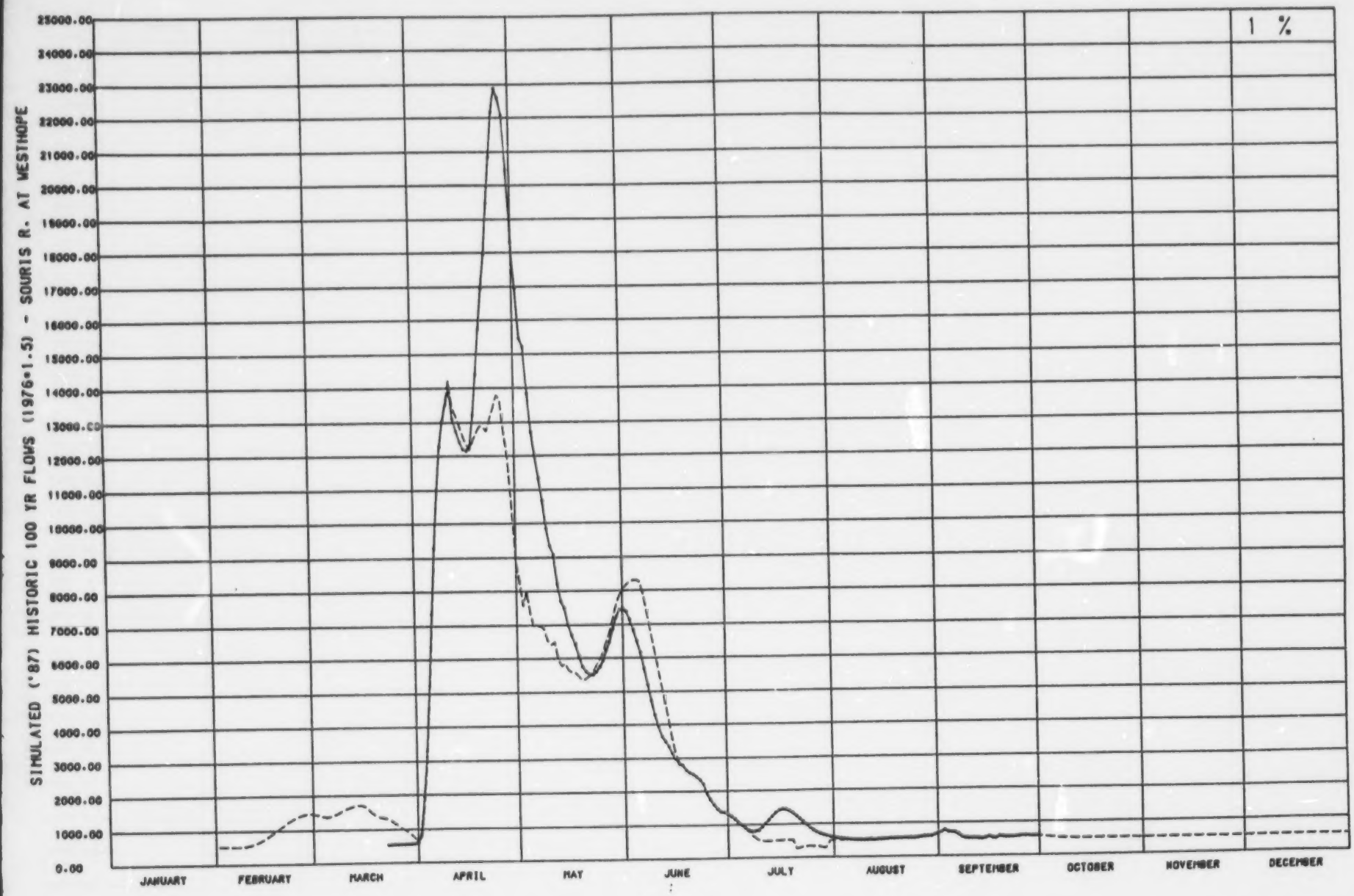
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

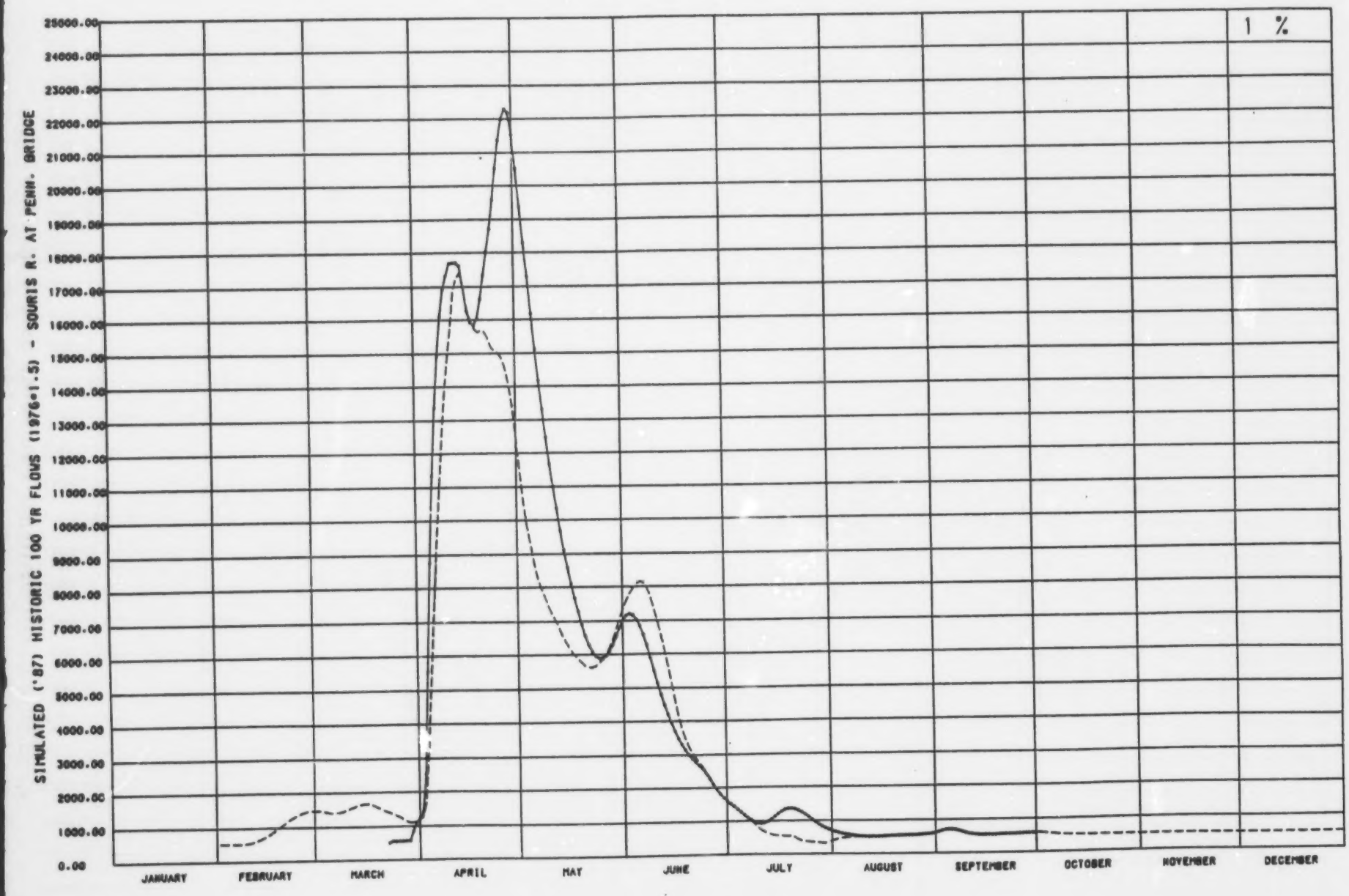

1979
SIMULATED FLOWS (CFS) SOURIS • LAUDER- HISTORIC (solid) RAFFERTY (dashed)
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

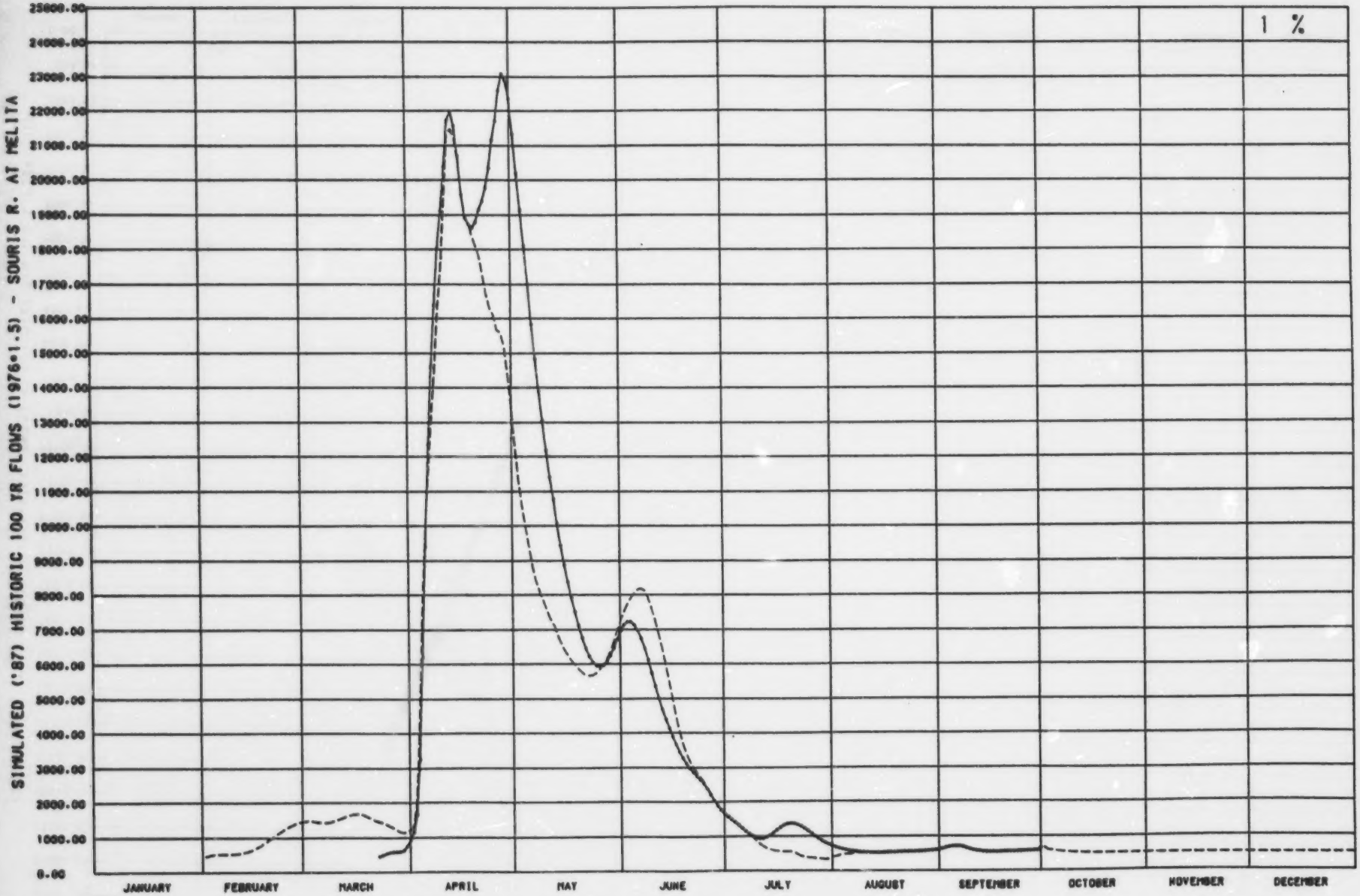

1979
SIMULATED FLOWS (CFS) SOURIS @ HARTNEY - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

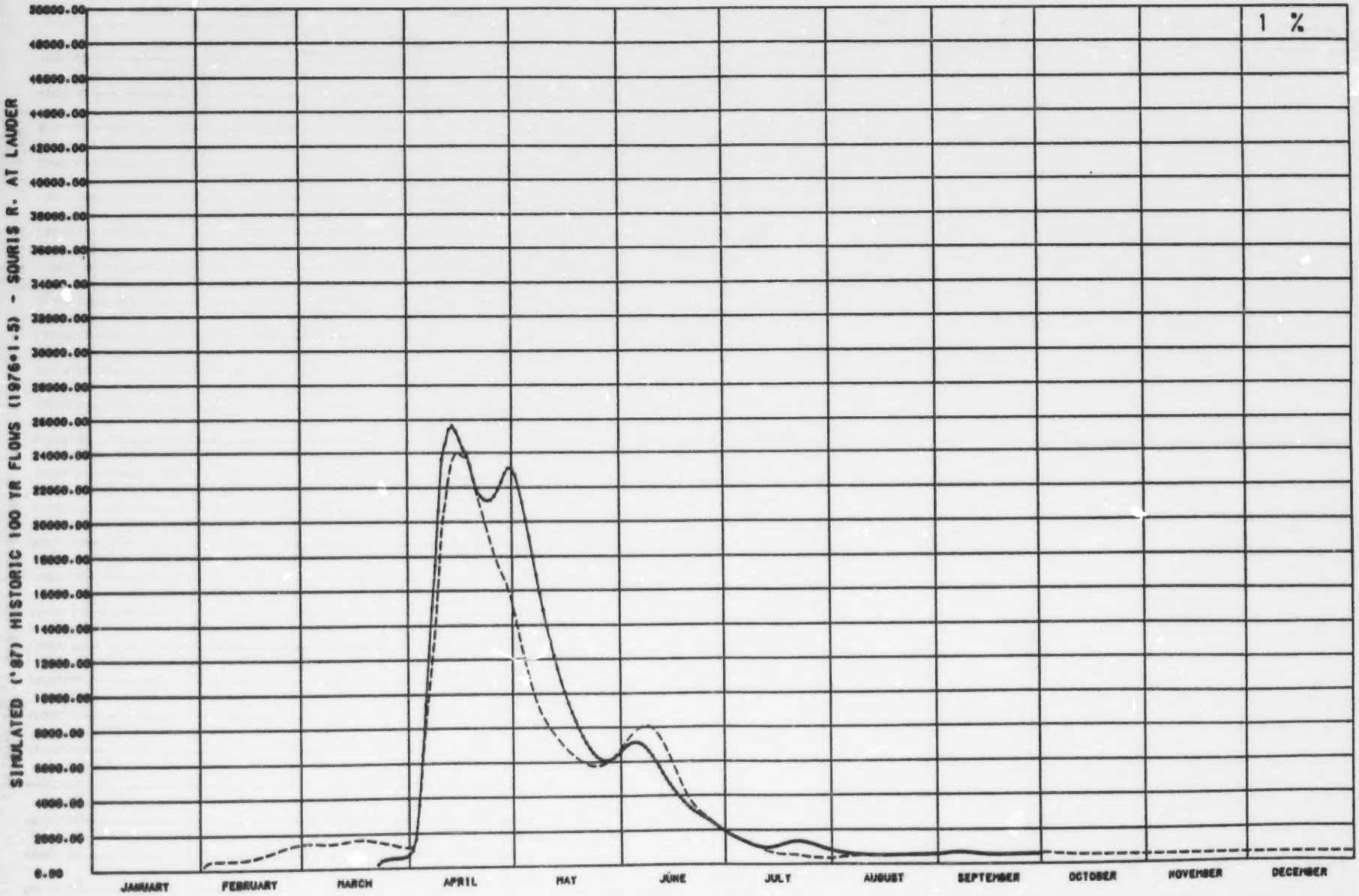

1979
SIMULATED FLOWS (CFS) SOURIS • SOURIS - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

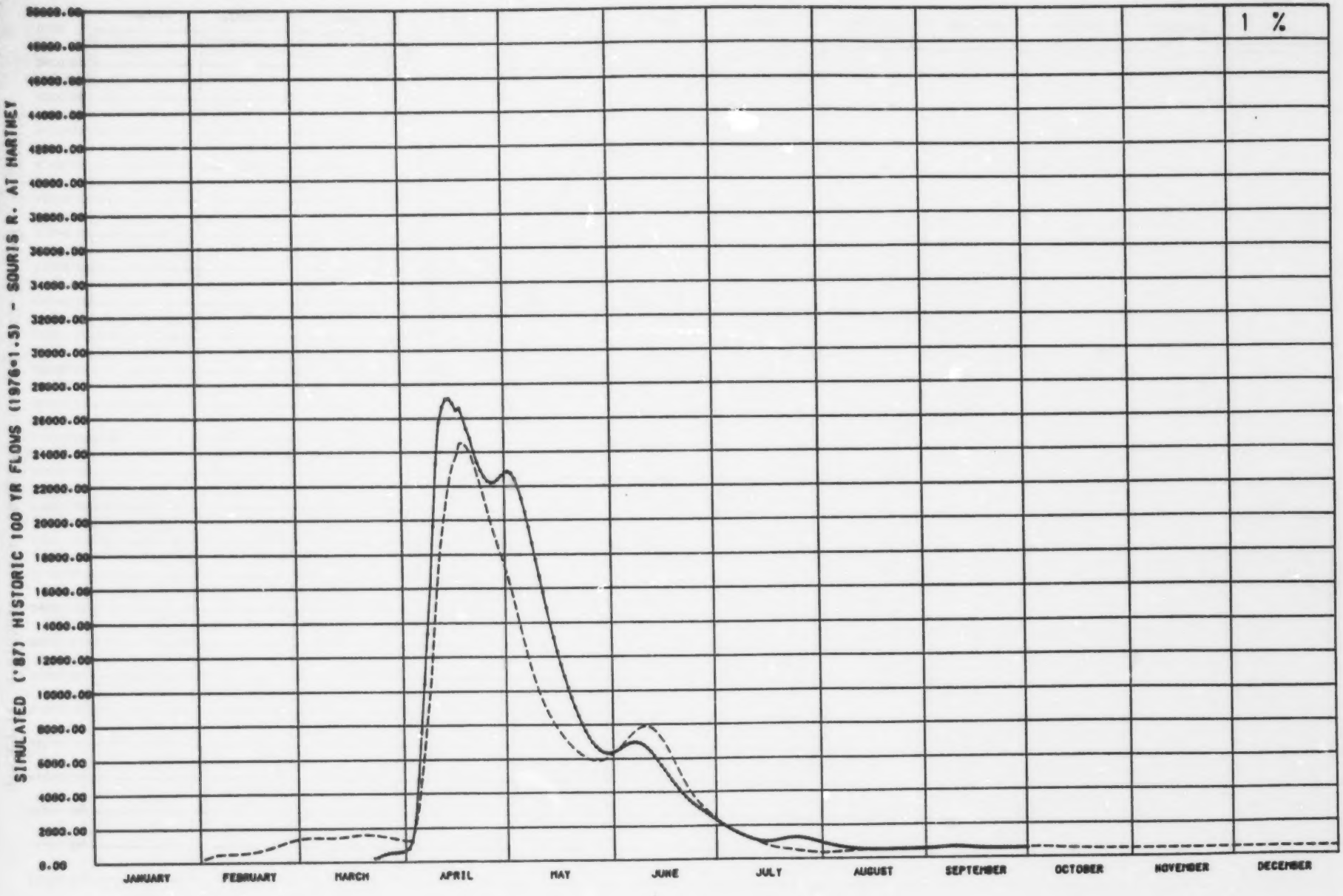

1979
SIMULATED FLOWS (CFS) SOURIS @ WAWANESA - HISTORIC (solid) RAFFERTY (dashed)
12500.00
12000.00
11500.00
11000.00
10500.00
10000.00
9500.00
9000.00
8500.00
8000.00
7500.00
7000.00
6500.00
6000.00
5500.00
5000.00
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

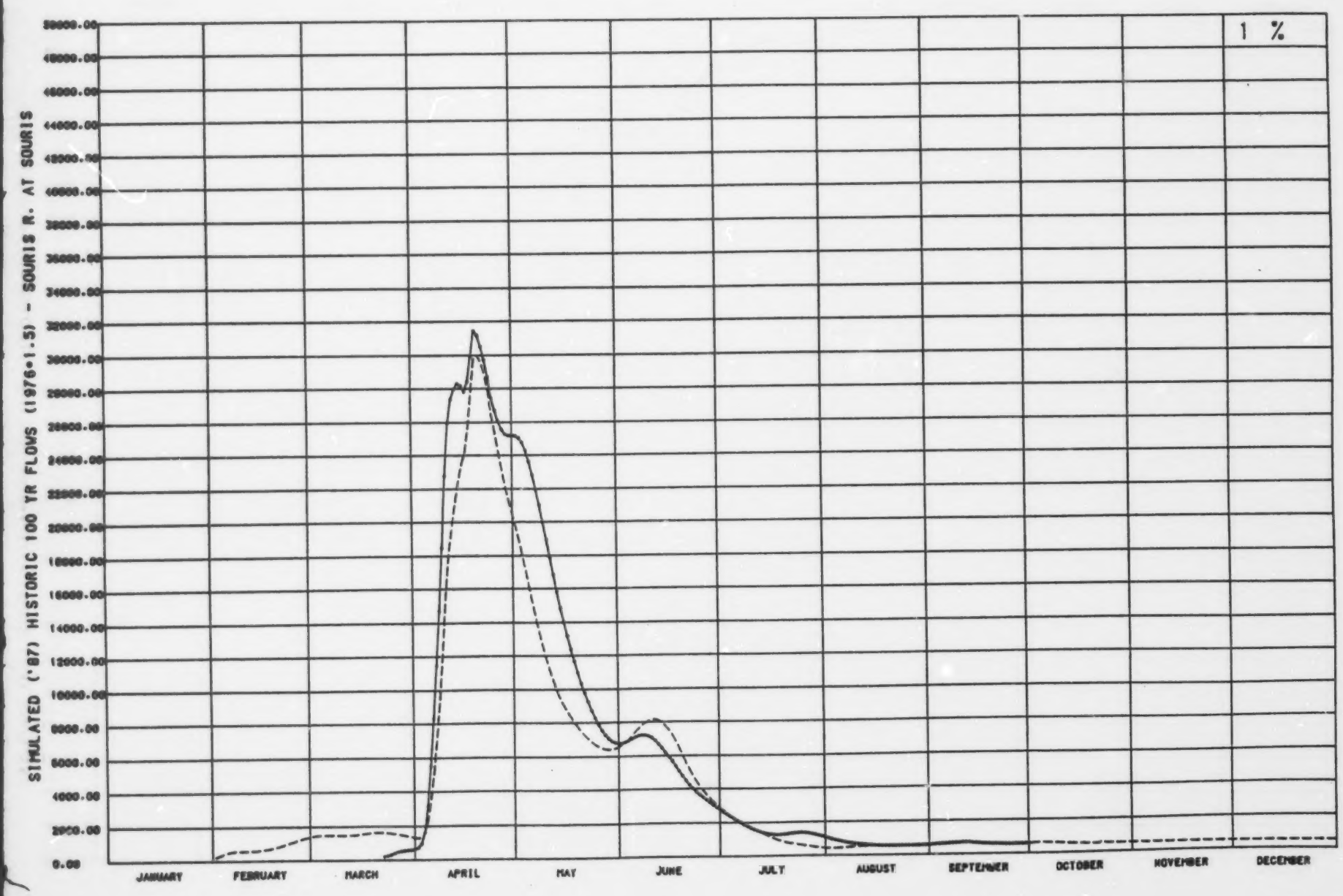

SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT WESTHOPE
25000.00
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
1 %
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

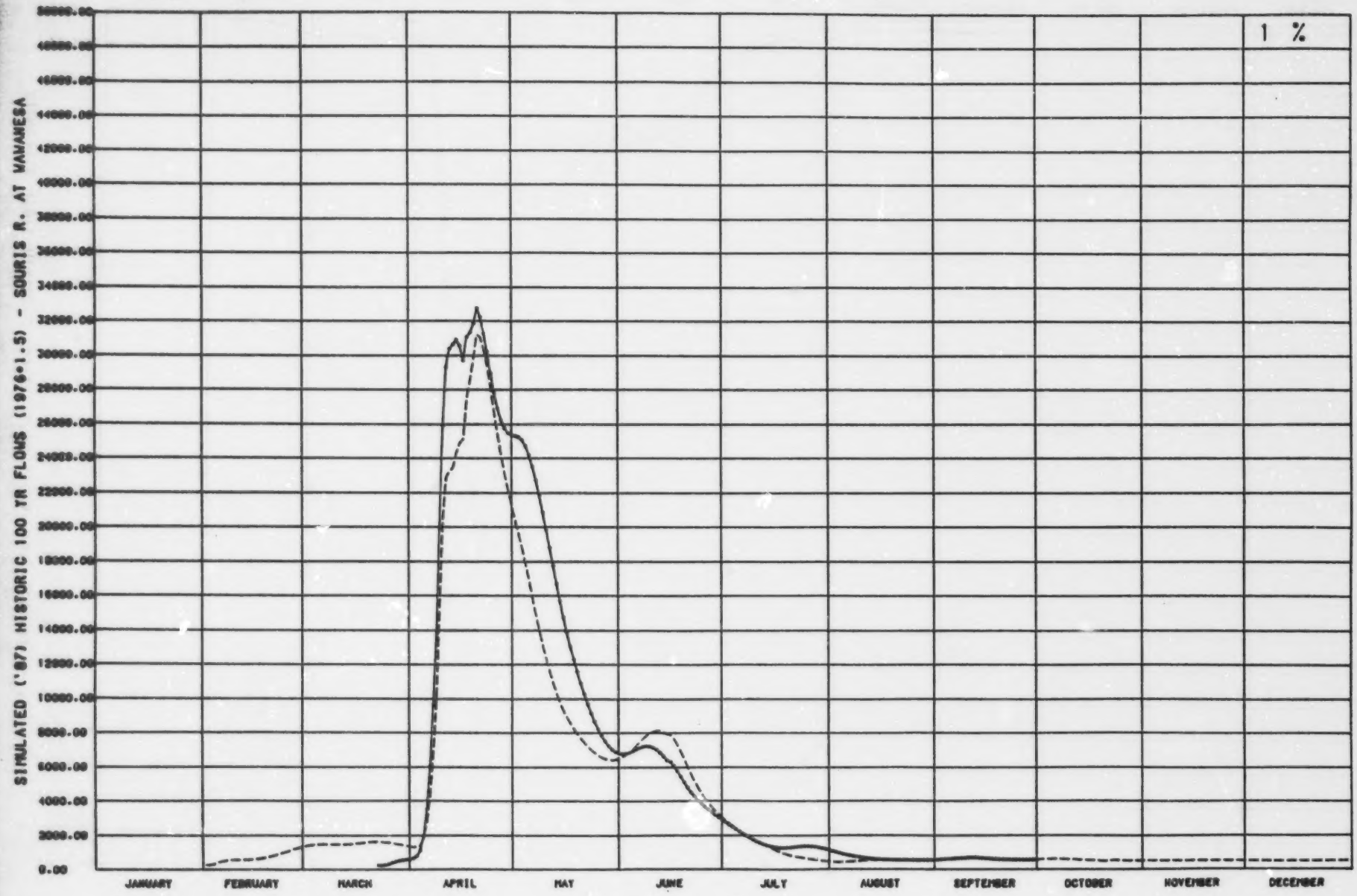

SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT PENN. BRIDGE
1 %
25000.00
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

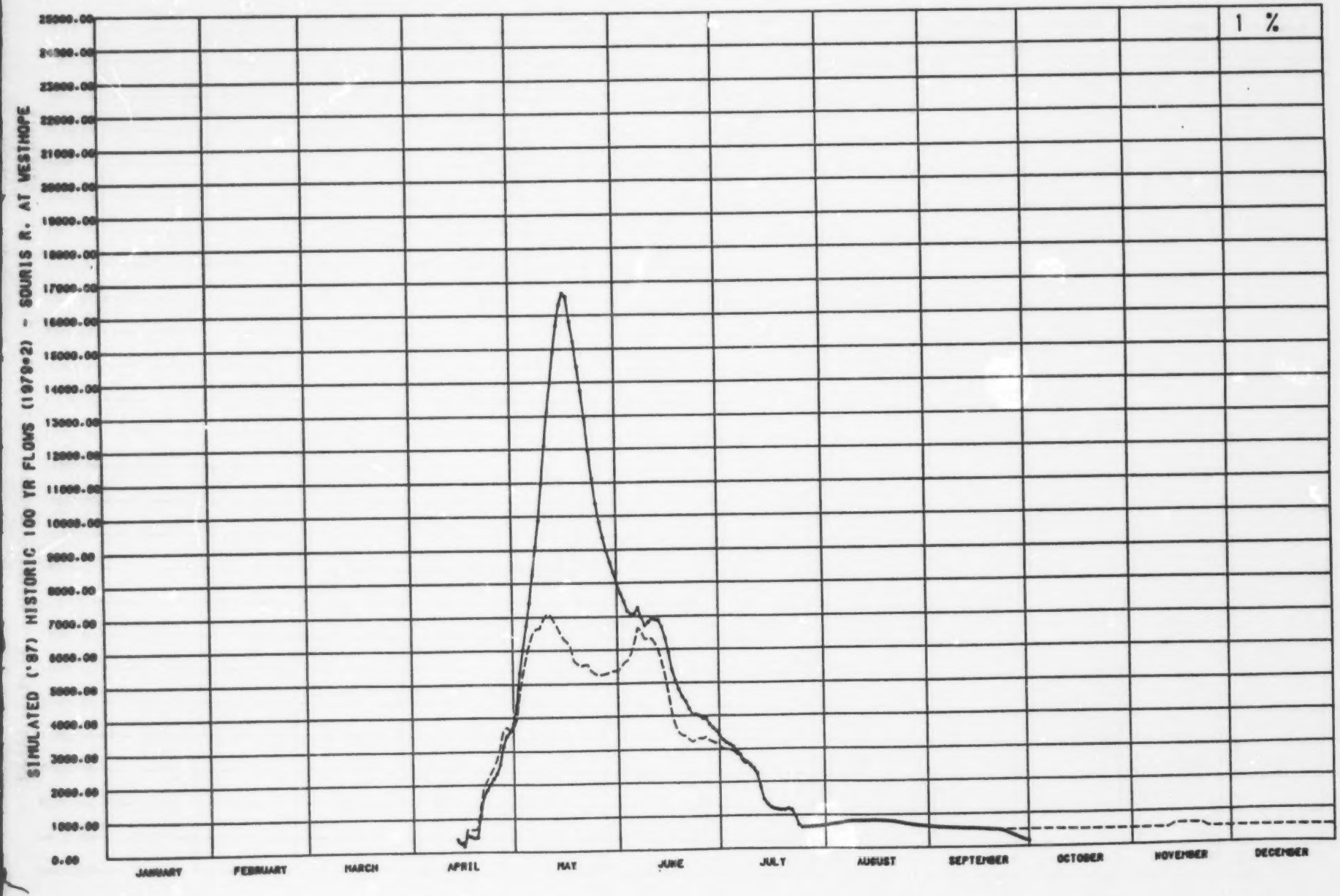

SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT MELITA
25000.00
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1 %

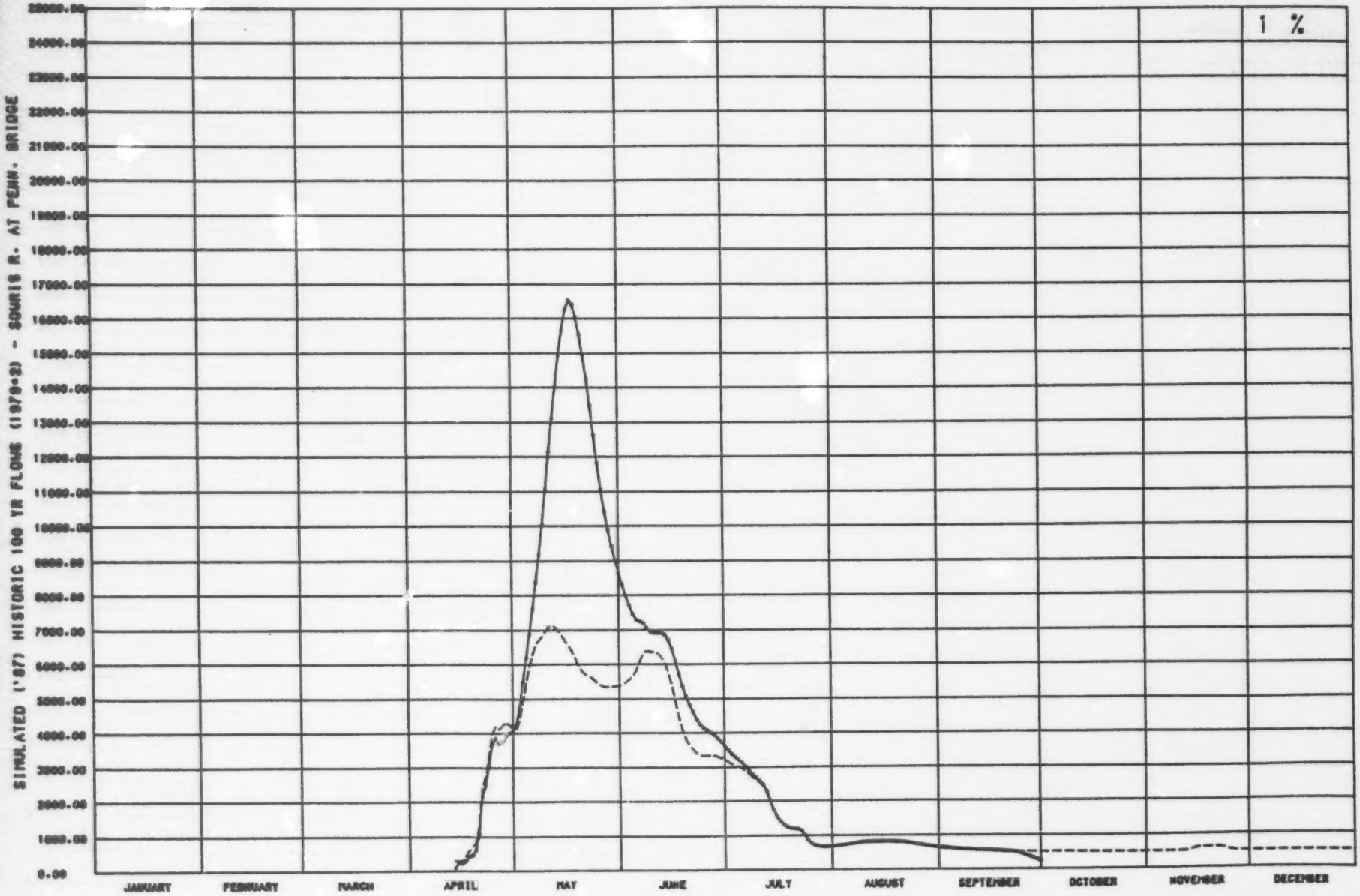

SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT LAUDER
1 %
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

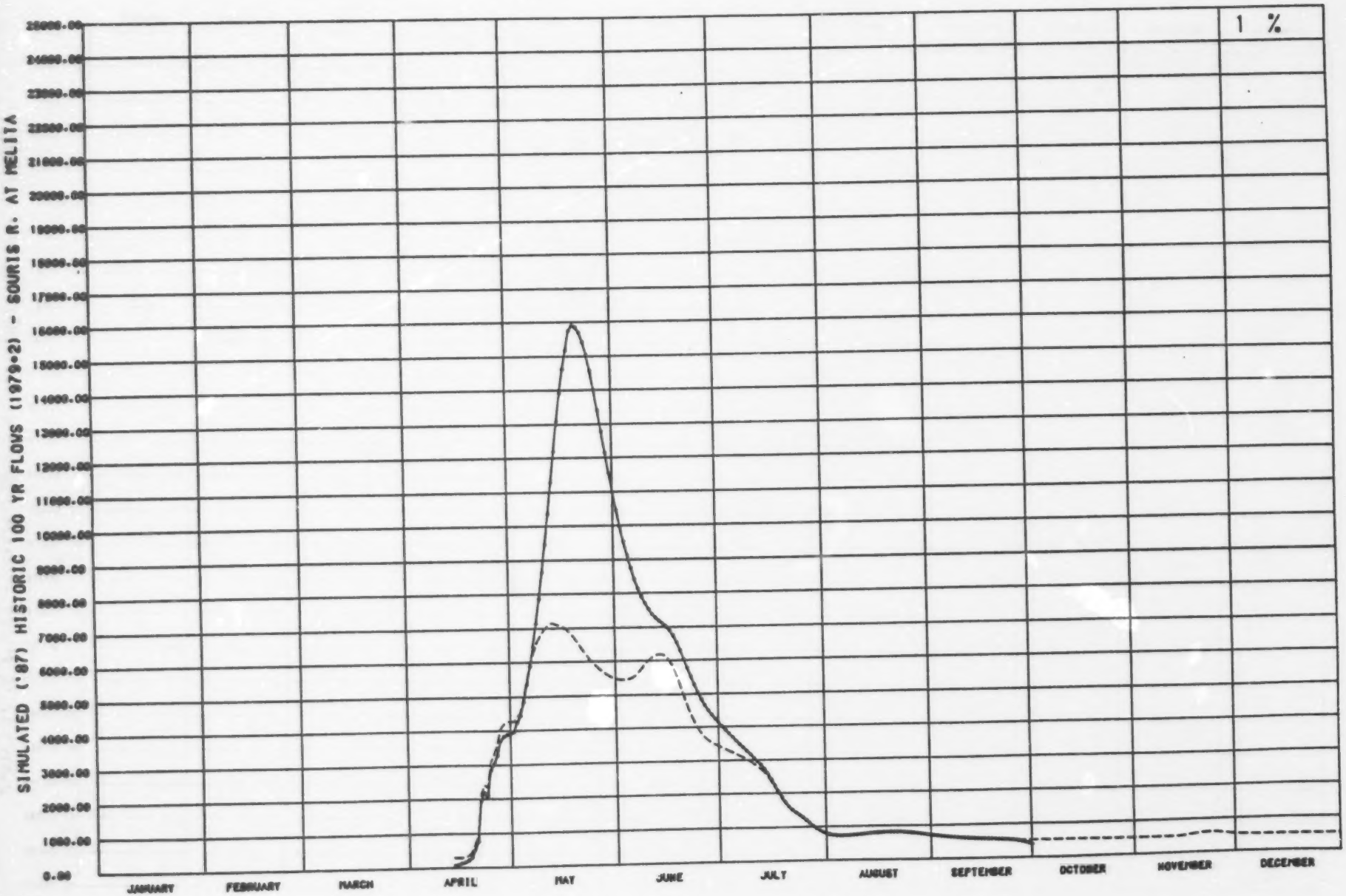

SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT HARTNEY
1 %
50000.00
48000.00
46000.00
44000.00
42000.00
40000.00
38000.00
36000.00
34000.00
32000.00
30000.00
28000.00
26000.00
24000.00
22000.00
20000.00
18000.00
16000.00
14000.00
12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT SOURIS
1 %
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('87) HISTORIC 100 YR FLOWS (1976+1.5) - SOURIS R. AT WAWANESA
1 %
0.00
2000.00
4000.00
6000.00
8000.00
10000.00
12000.00
14000.00
16000.00
18000.00
20000.00
22000.00
24000.00
26000.00
28000.00
30000.00
32000.00
34000.00
36000.00
38000.00
40000.00
42000.00
44000.00
46000.00
48000.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('97) HISTORIC 100 YR FLOWS (1979-2) - SOURIS R. AT WESTHOPE
25000.00
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1 %


SIMULATED ('87) HISTORIC 100 YR FLOWS (1979-2) - SOURIS R. AT PENN. BRIDGE
1 %
25000.00
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('87) HISTORIC 100 YR FLOWS (1979-2) - SOURIS R. AT MELITA
1 %
25000.00
24000.00
23000.00
22000.00
21000.00
20000.00
19000.00
18000.00
17000.00
16000.00
15000.00
14000.00
13000.00
12000.00
11000.00
10000.00
9000.00
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
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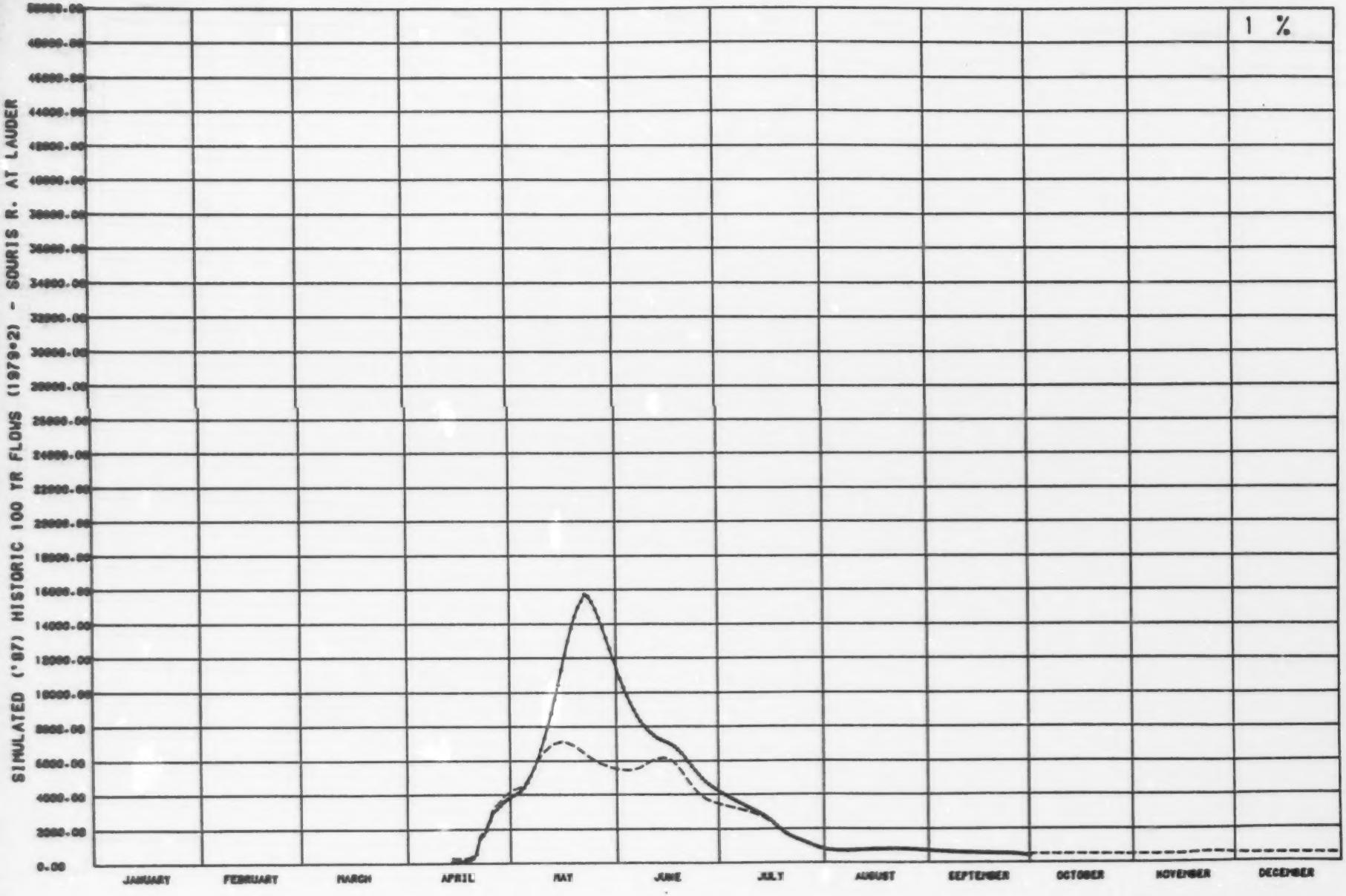
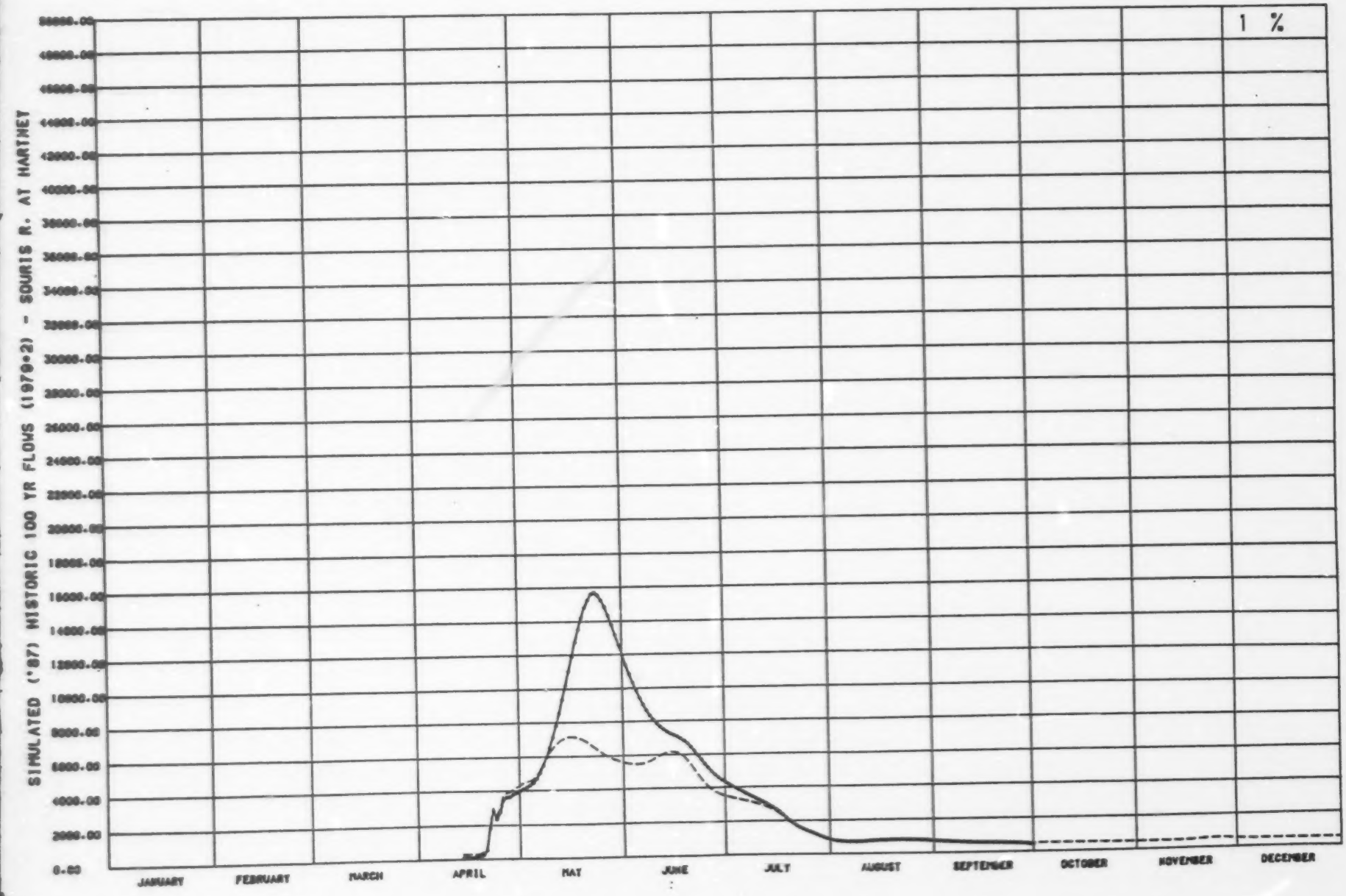
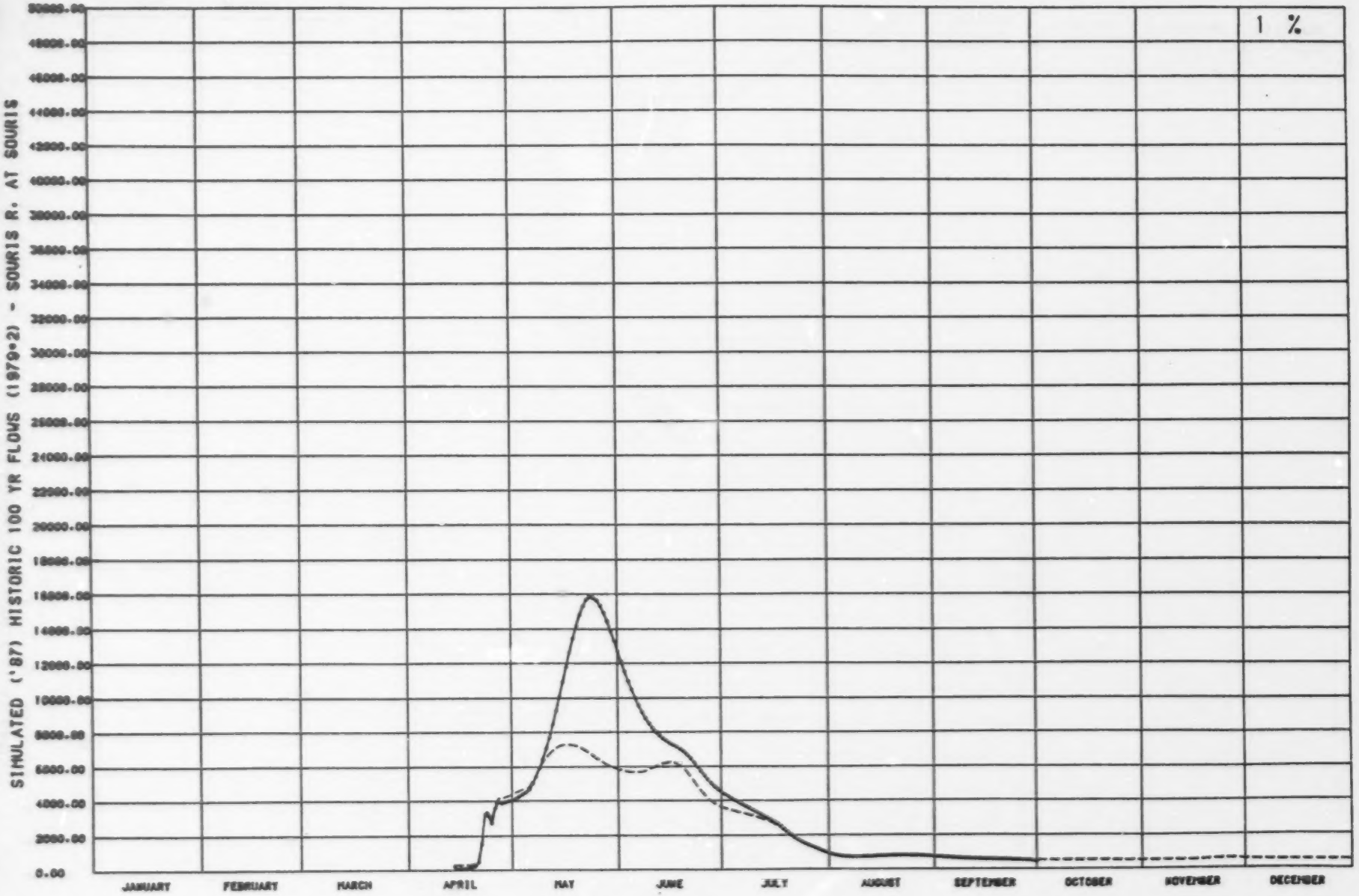
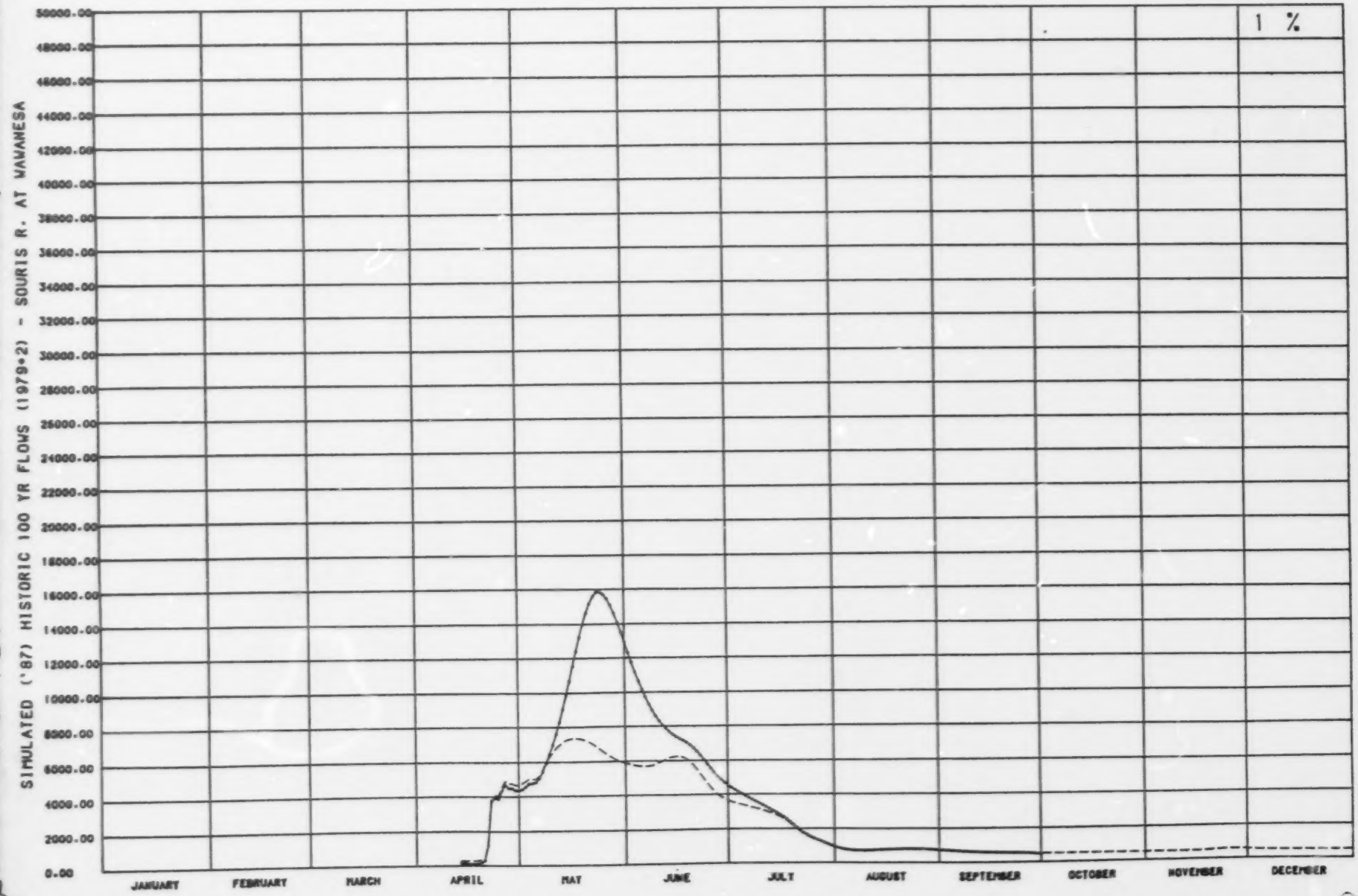
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('87) HISTORIC 100 YR FLOWS (1979-2) - SOURIS R. AT LAUDER
1 %
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('87) HISTORIC 100 YR FLOWS (1979•2) - SOURIS R. AT HARTNEY
1 %
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER


SIMULATED ('87) HISTORIC 100 YR FLOWS (1979-2) - SOURIS R. AT SOURIS
50000.00
48000.00
46000.00
44000.00
42000.00
40000.00
38000.00
36000.00
34000.00
32000.00
30000.00
28000.00
26000.00
24000.00
22000.00
20000.00
18000.00
16000.00
14000.00
12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
1 %


SIMULATED ('87) HISTORIC 100 YR FLOWS (1979-2) - SOURIS R. AT WAWANESA
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FEBRUARY
MARCH
APRIL
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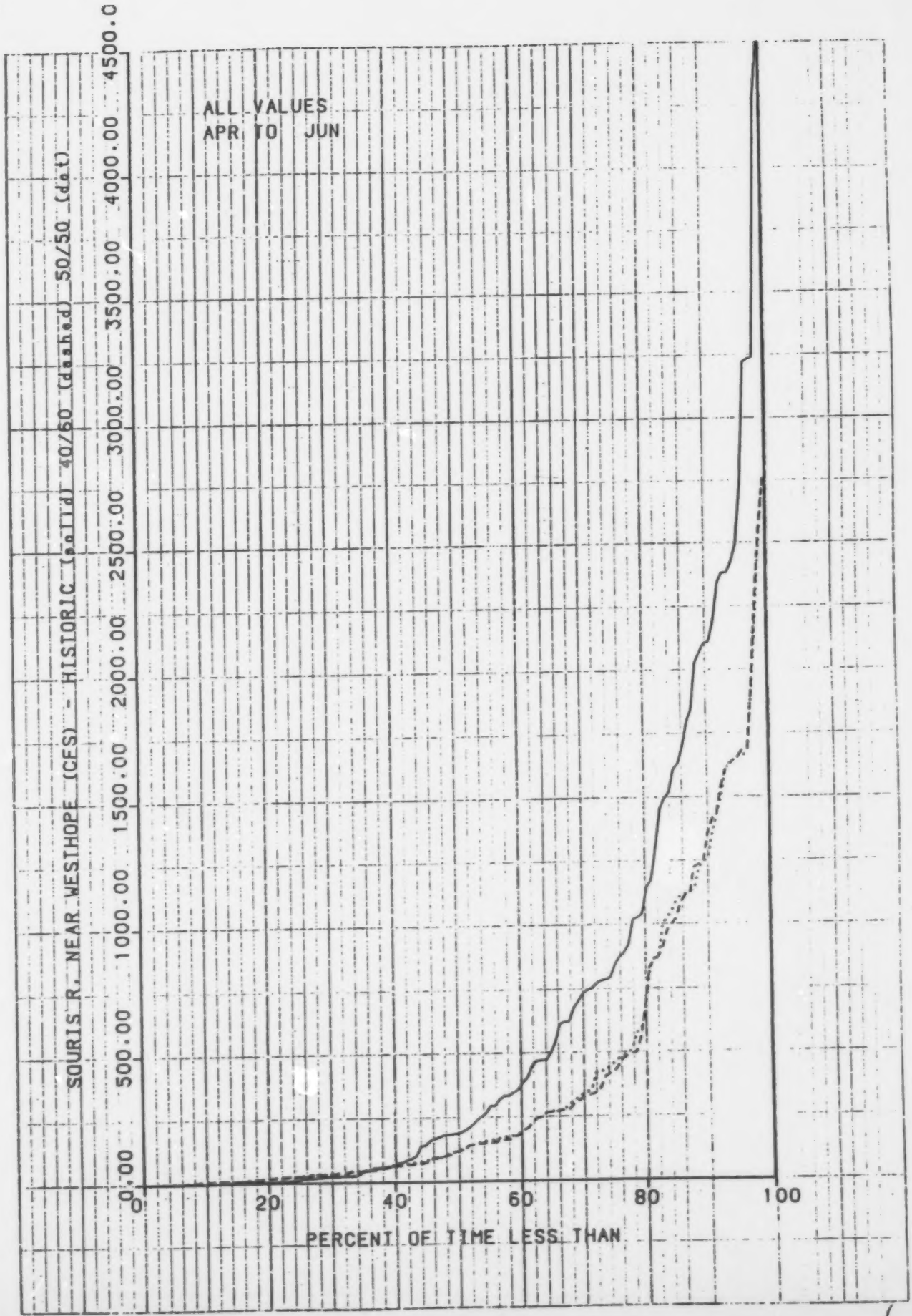
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

Attachment B

Flow Duration Curves for
Full Project Operation


ALL VALUES
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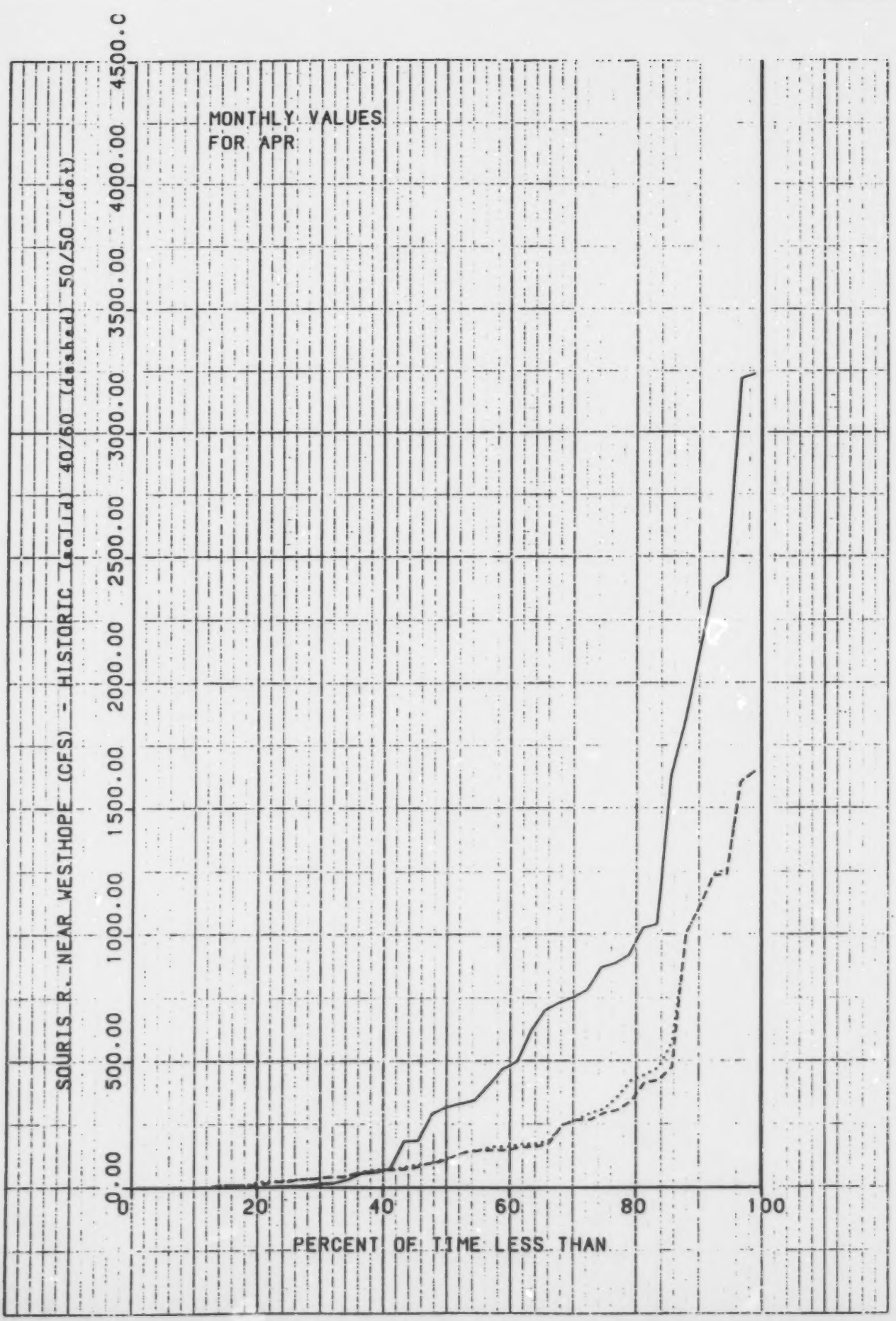
MONTHLY VALUES
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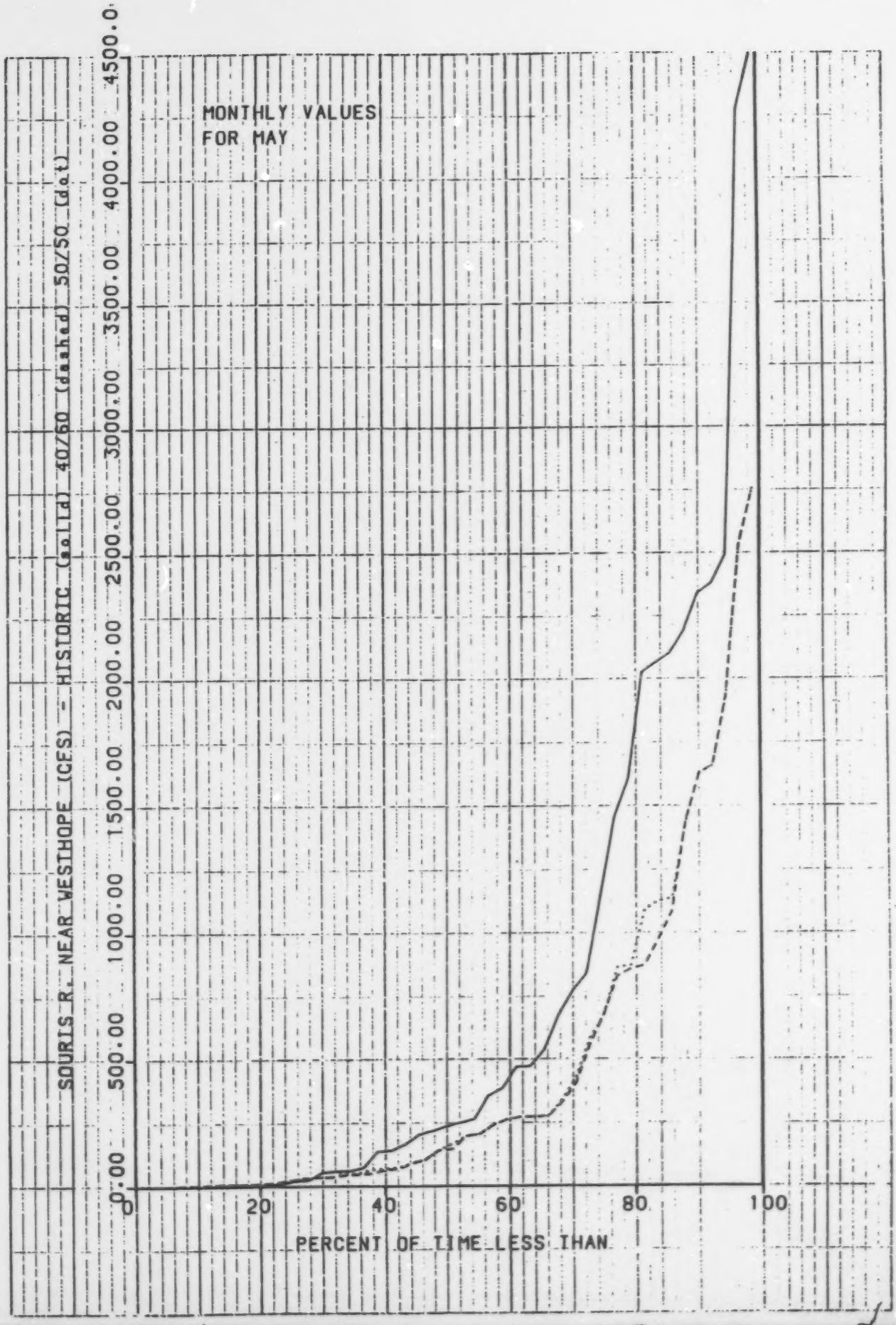
MONTHLY VALUES
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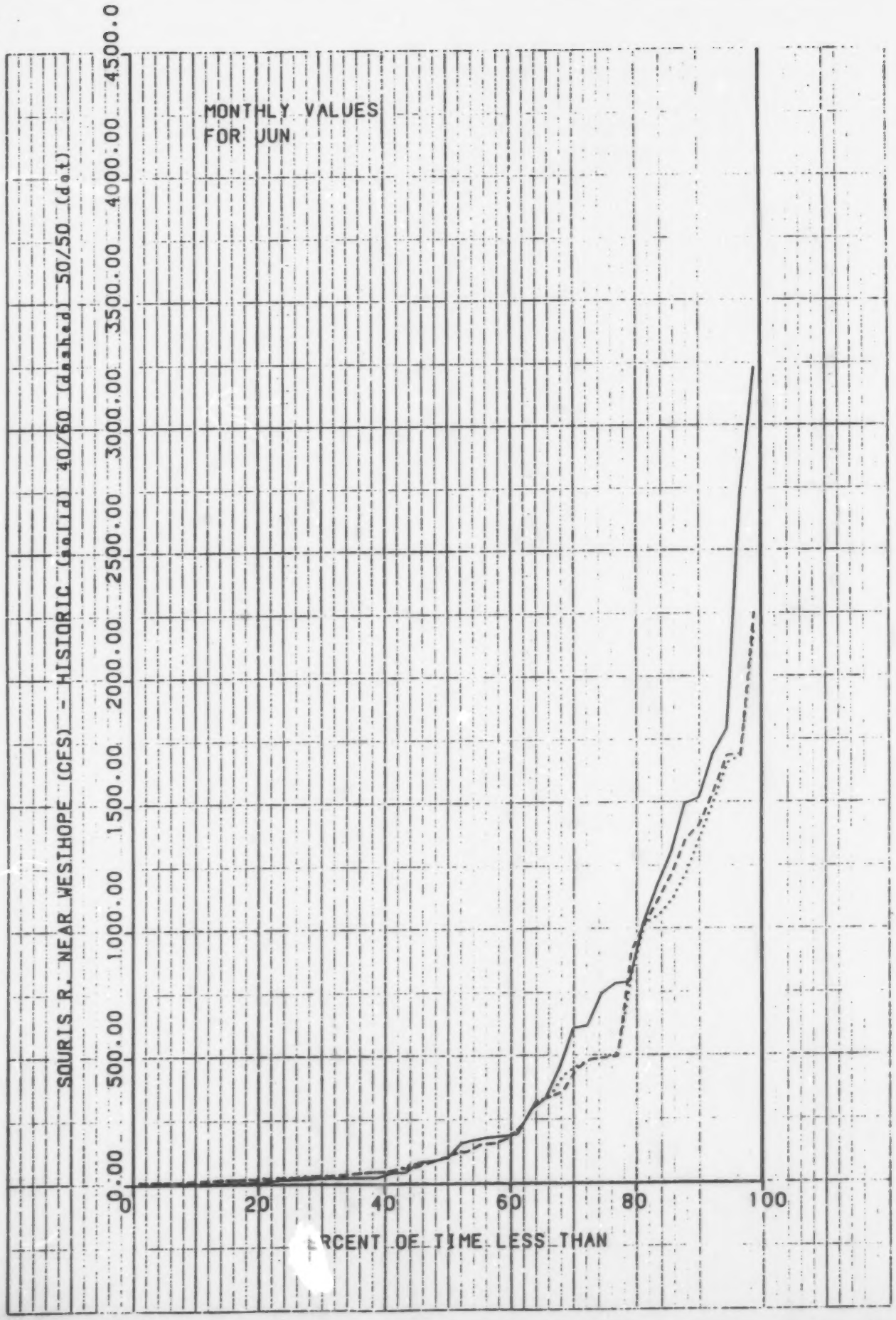
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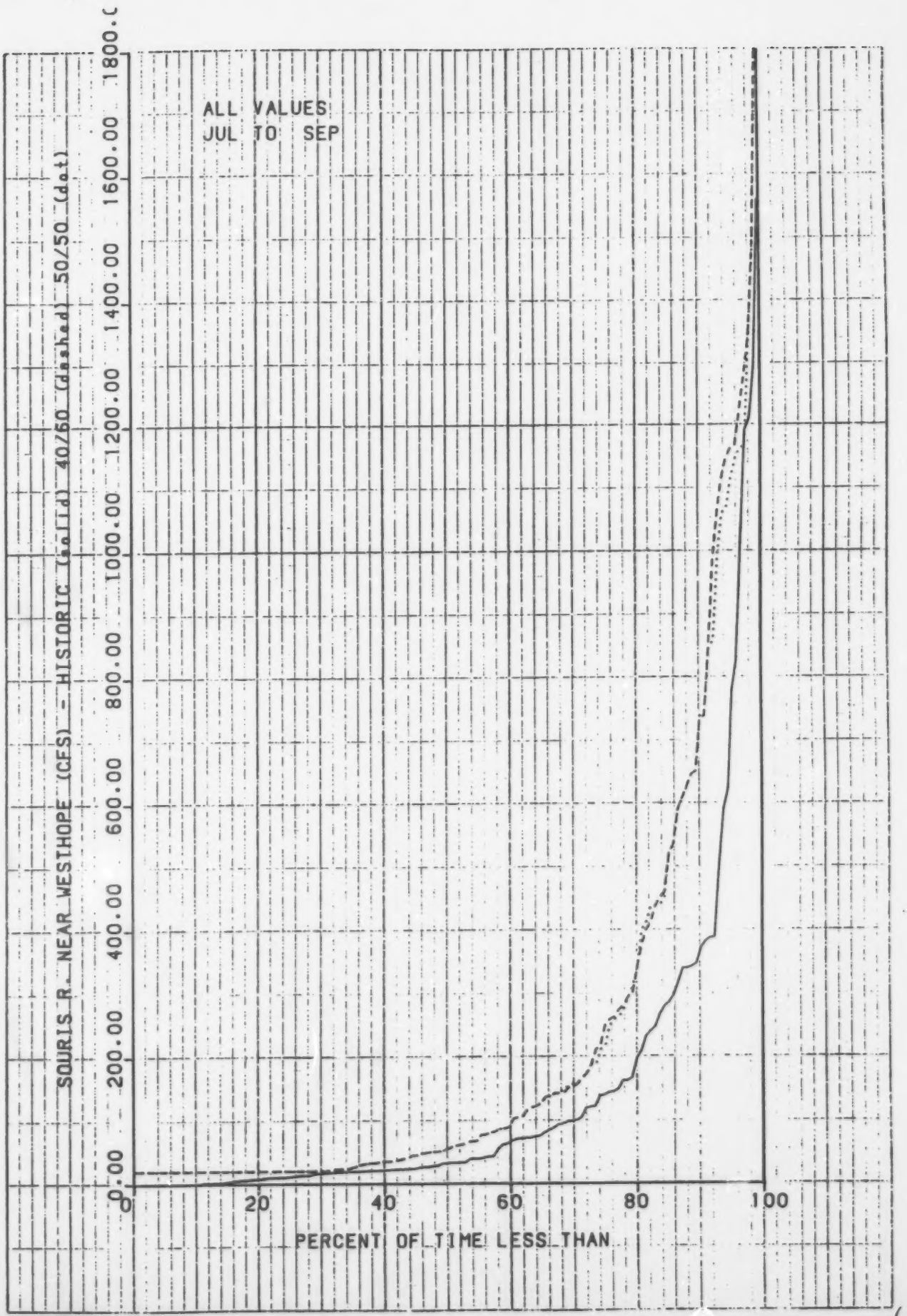
ALL VALUES
JUL TO SEP
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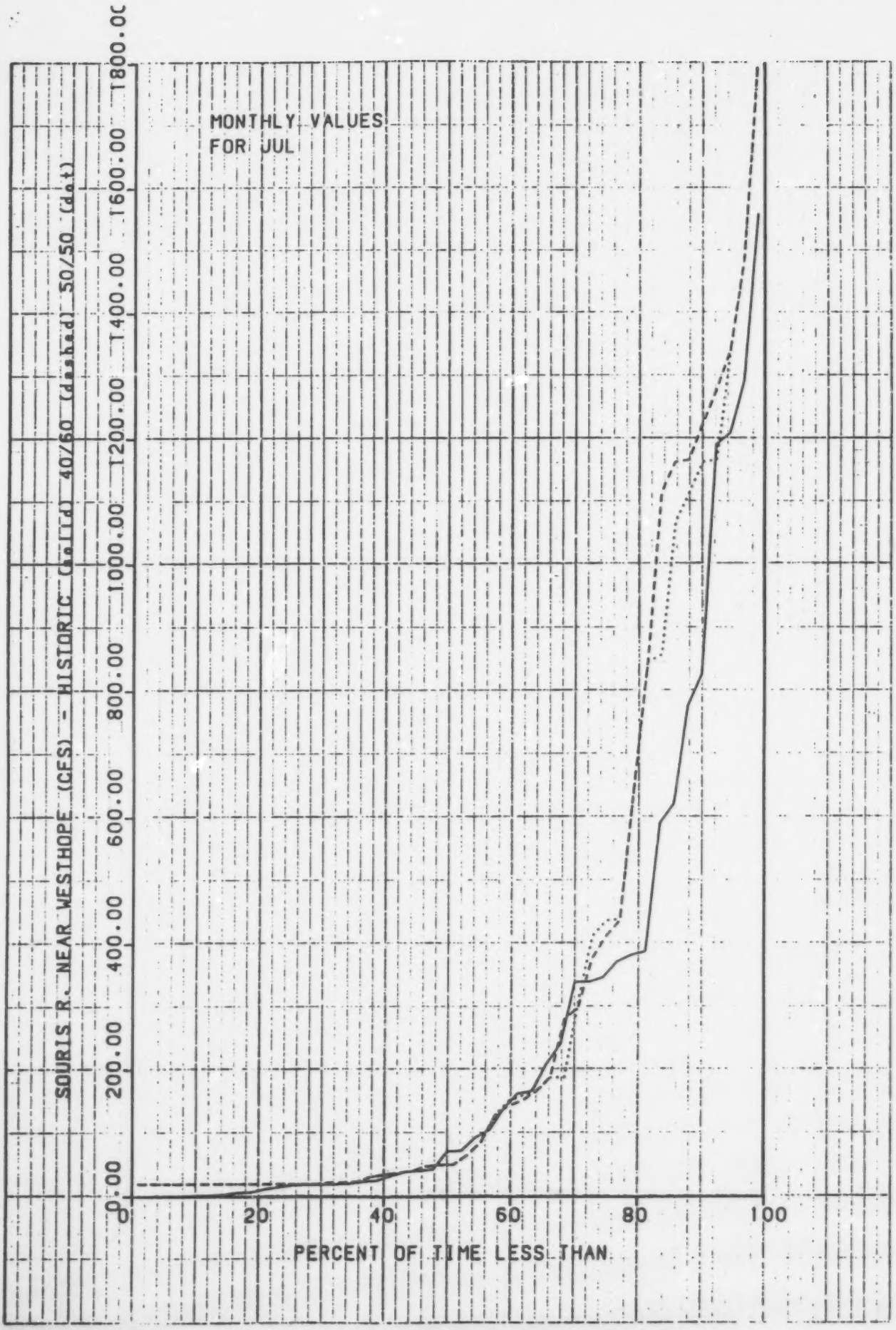
MONTHLY VALUES
FOR JUL
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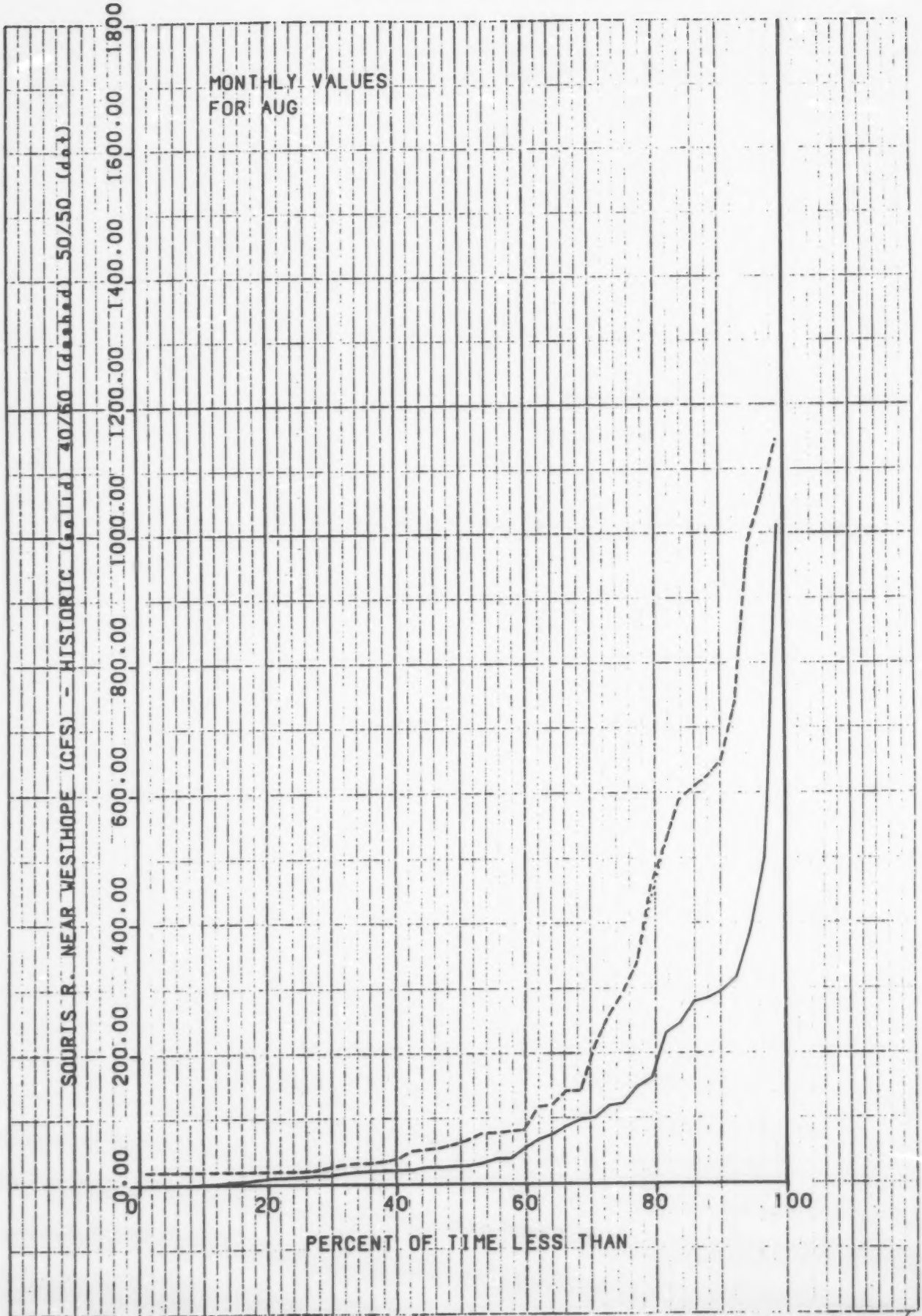
MONTHLY VALUES
FOR AUG
SOURIS R. NEAR WESTHOPE (CES) - HISTORIC (solid) 40/60 (dashed) 50/50 (dot)
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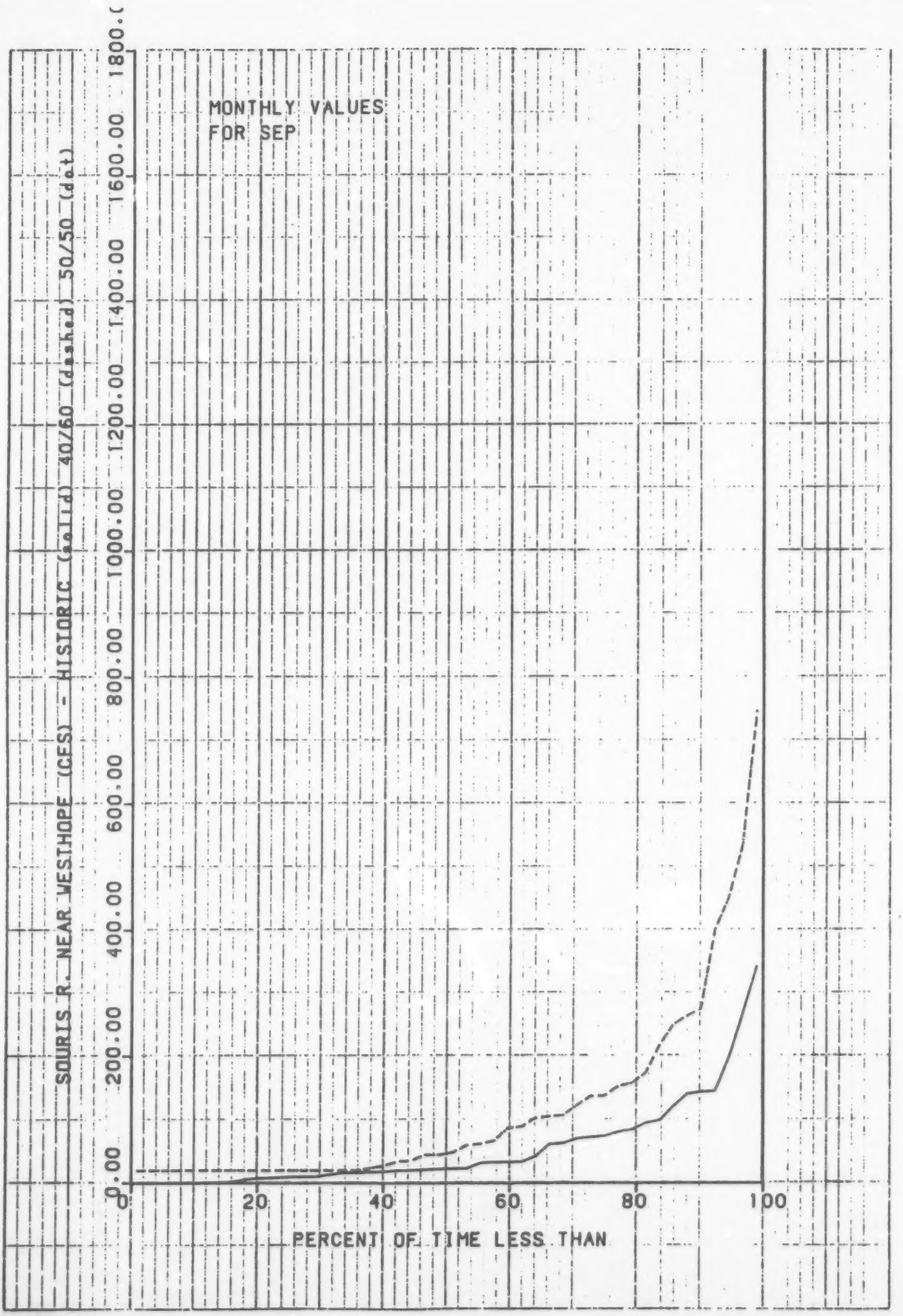
PERCENT OF TIME LESS THAN


MONTHLY VALUES
FOR SEP
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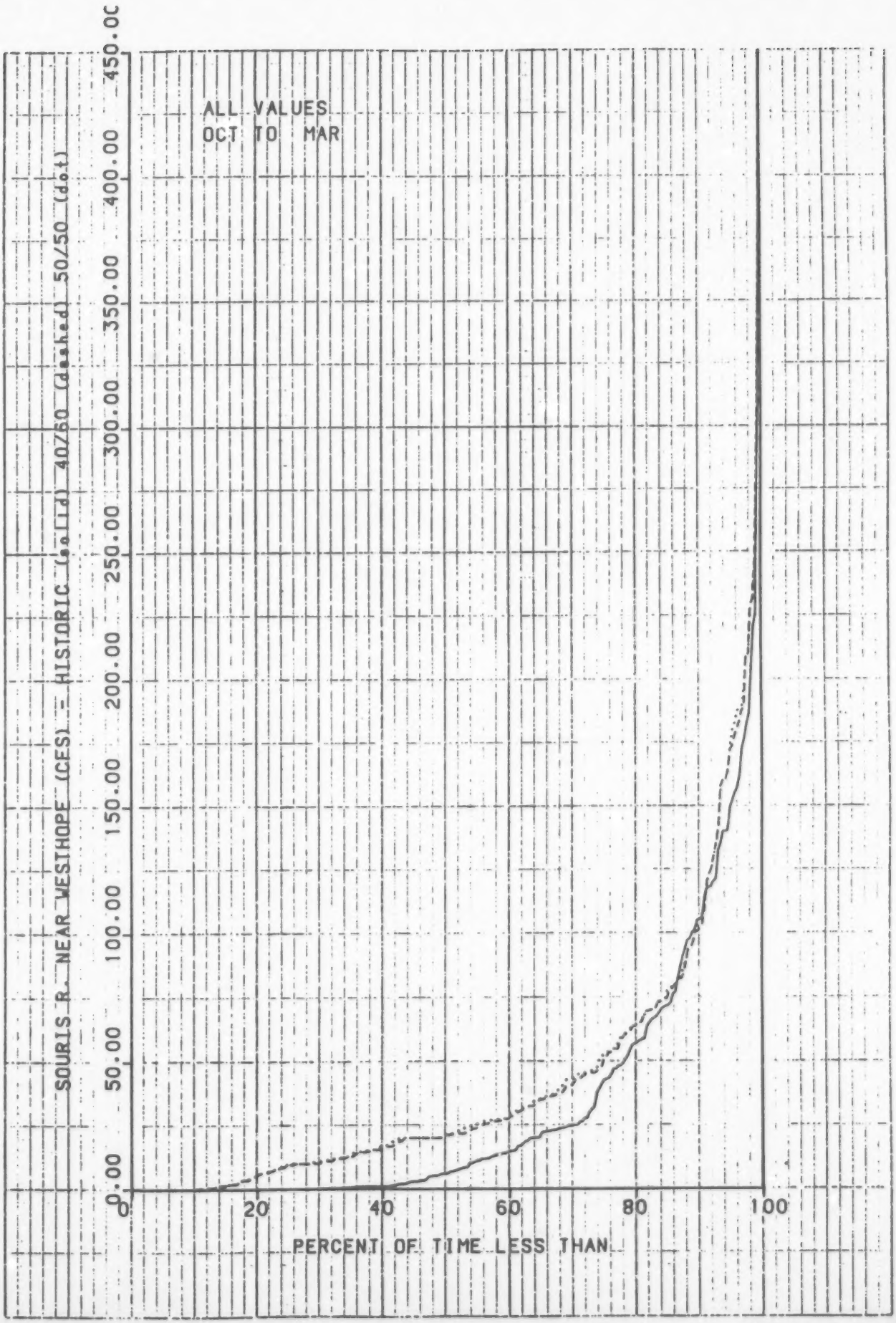
PERCENT OF TIME LESS THAN


ALL VALUES
OCT TO MAR
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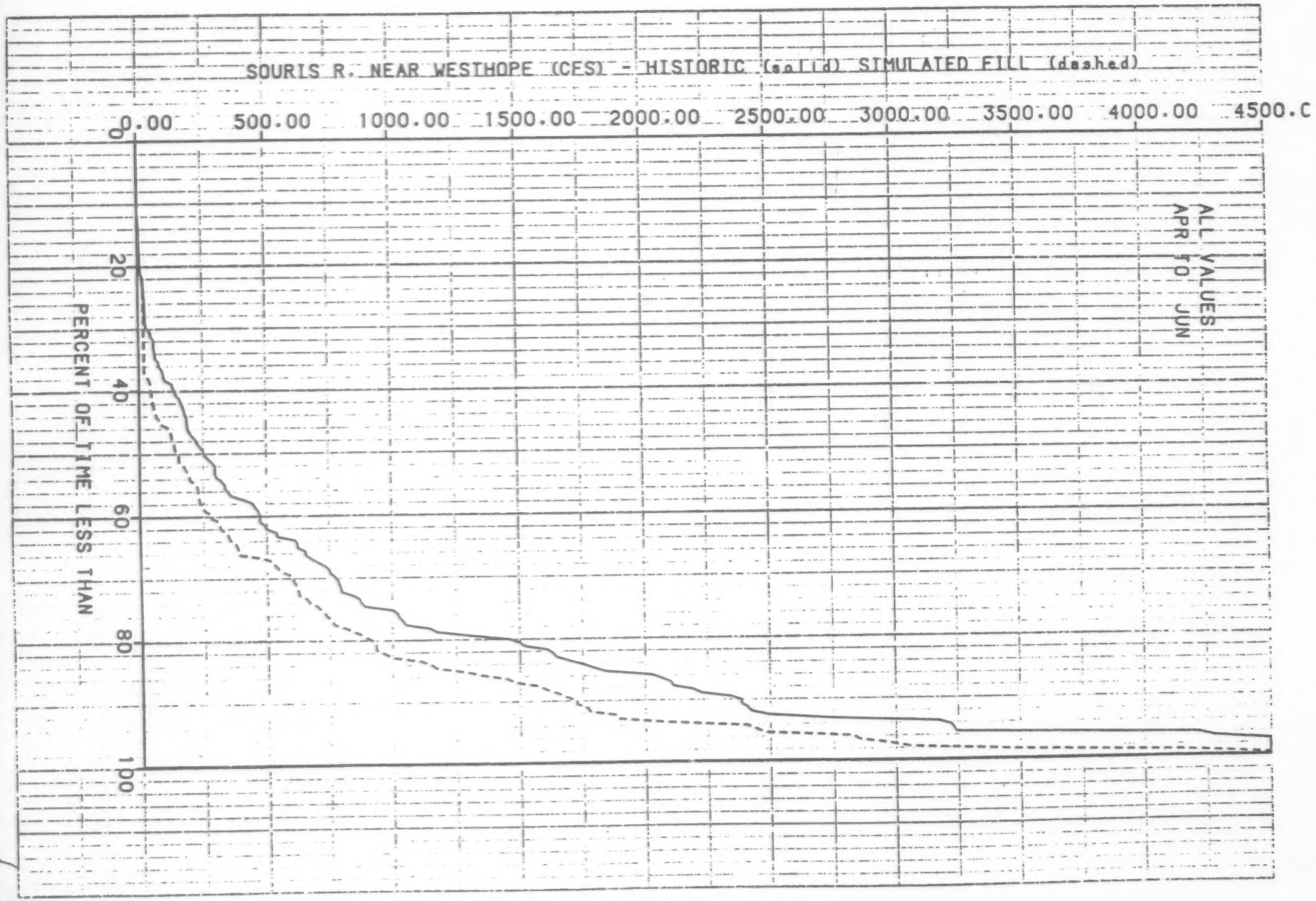
PERCENT OF TIME LESS THAN

Attachment C

Flow Duration Curves for
Reservoir Filling Phase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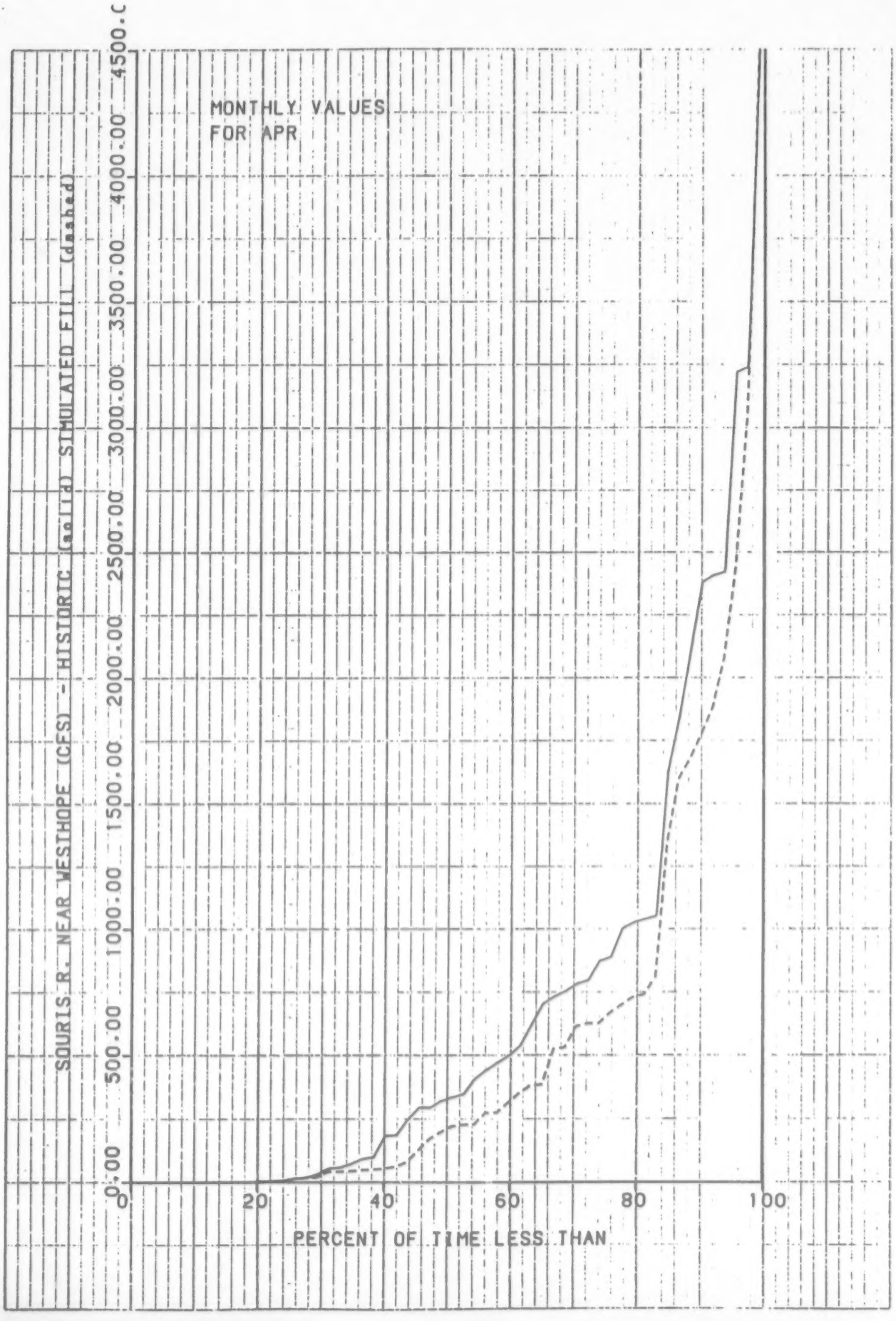
PERCENT OF TIME LESS THAN
ALL VALUES
APR TO JUN


MONTHLY VALUES
FOR APR
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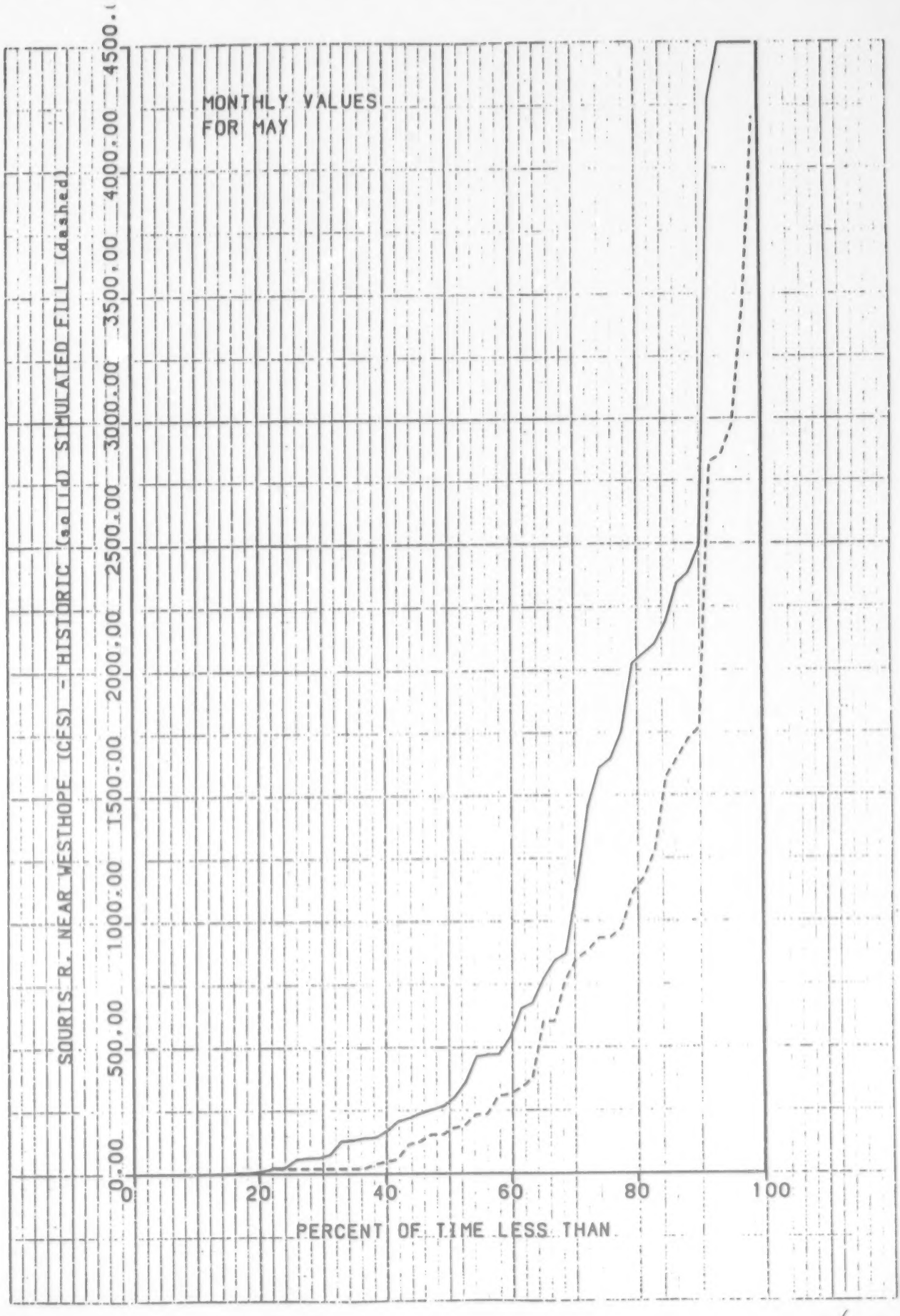
PERCENT OF TIME LESS THAN


MONTHLY VALUES
FOR MAY
SOURIS R. NEAR WESTHOPE (CES) - HISTORIC (solid) SIMULATED FILL (dashed)
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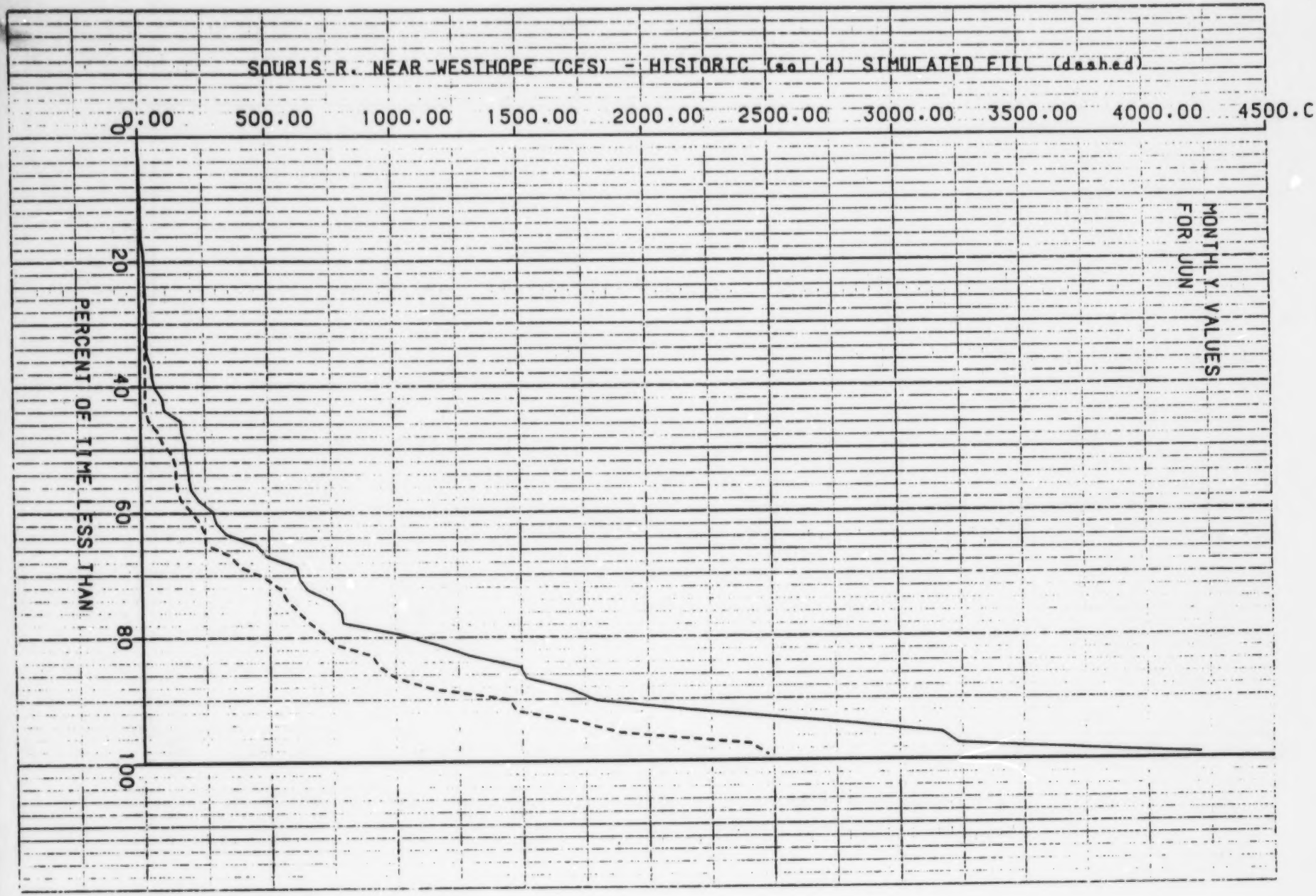
PERCENT OF TIME LESS THAN


SOURIS R. NEAR WESTHOPE (CFS) - HISTORIC (solid) SIMULATED FILL (dashed)
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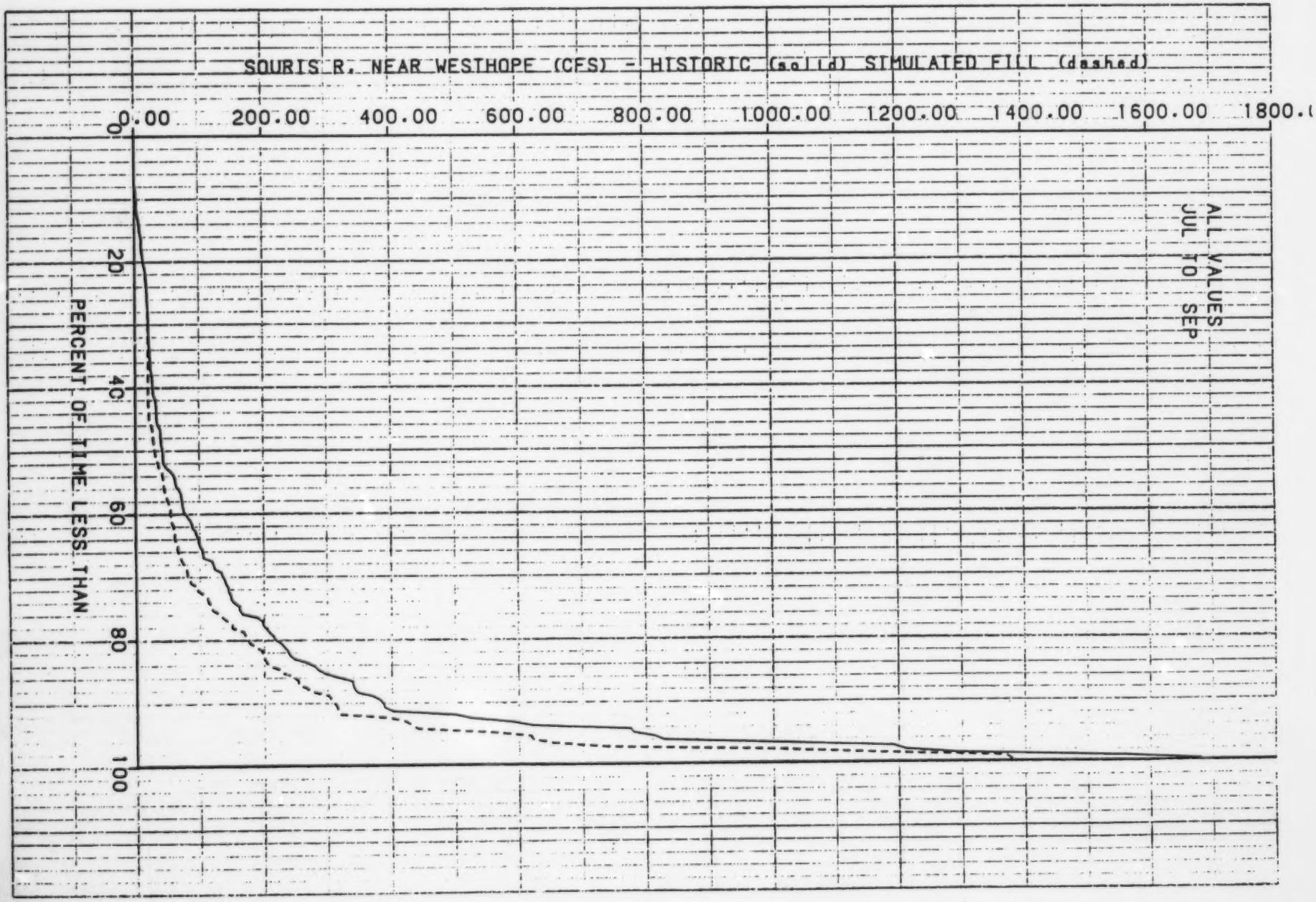
PERCENT OF TIME LESS THAN
MONTHLY VALUES
FOR JUN


SOURIS R. NEAR WESTHOPE (CFS) - HISTORIC (solid) SIMULATED FILL (dashed)
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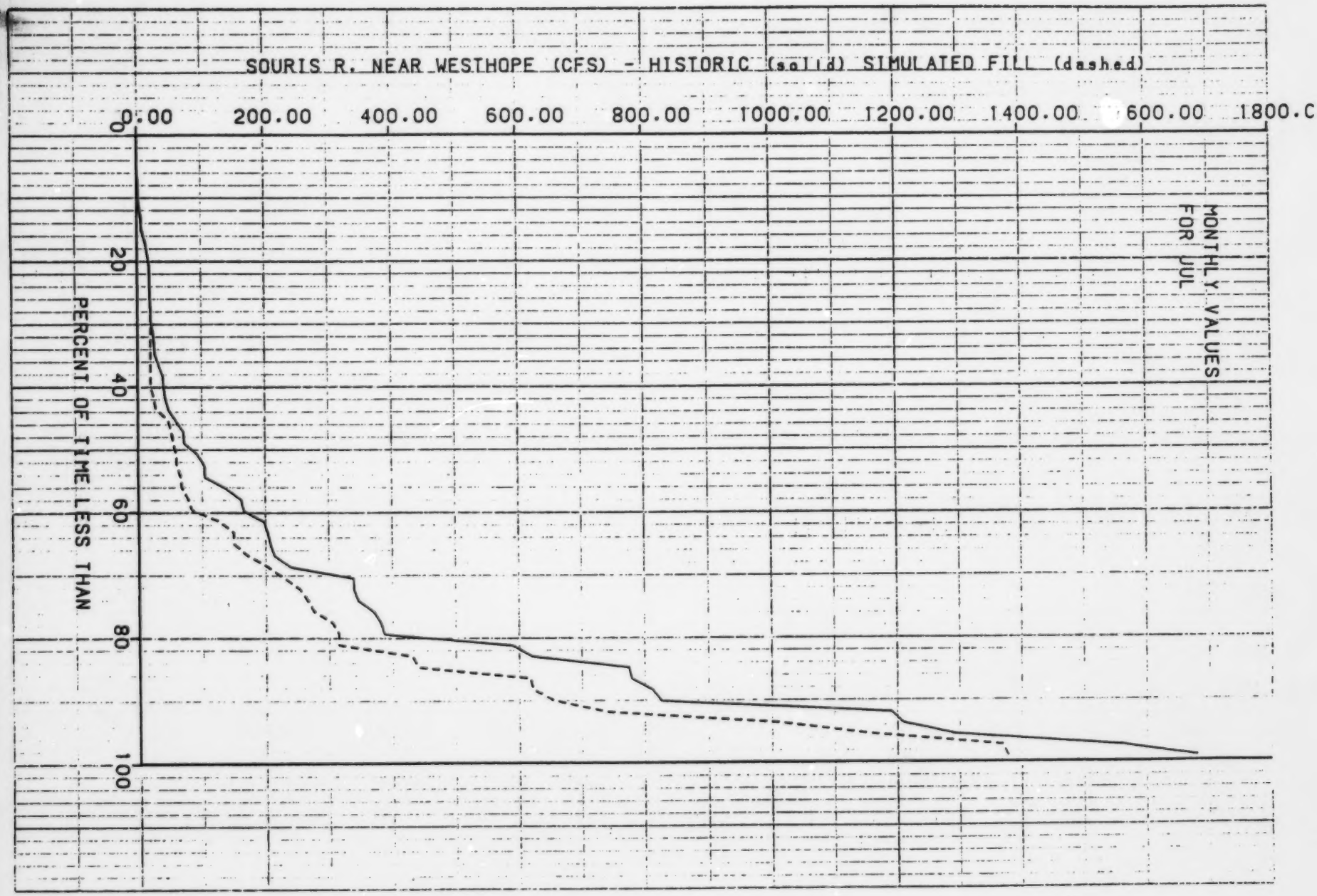
PERCENT OF TIME LESS THAN
ALL VALUES
JUL TO SEP


SOURIS R. NEAR WESTHOPE (CFS) - HISTORIC (solid) SIMULATED FILL (dashed)
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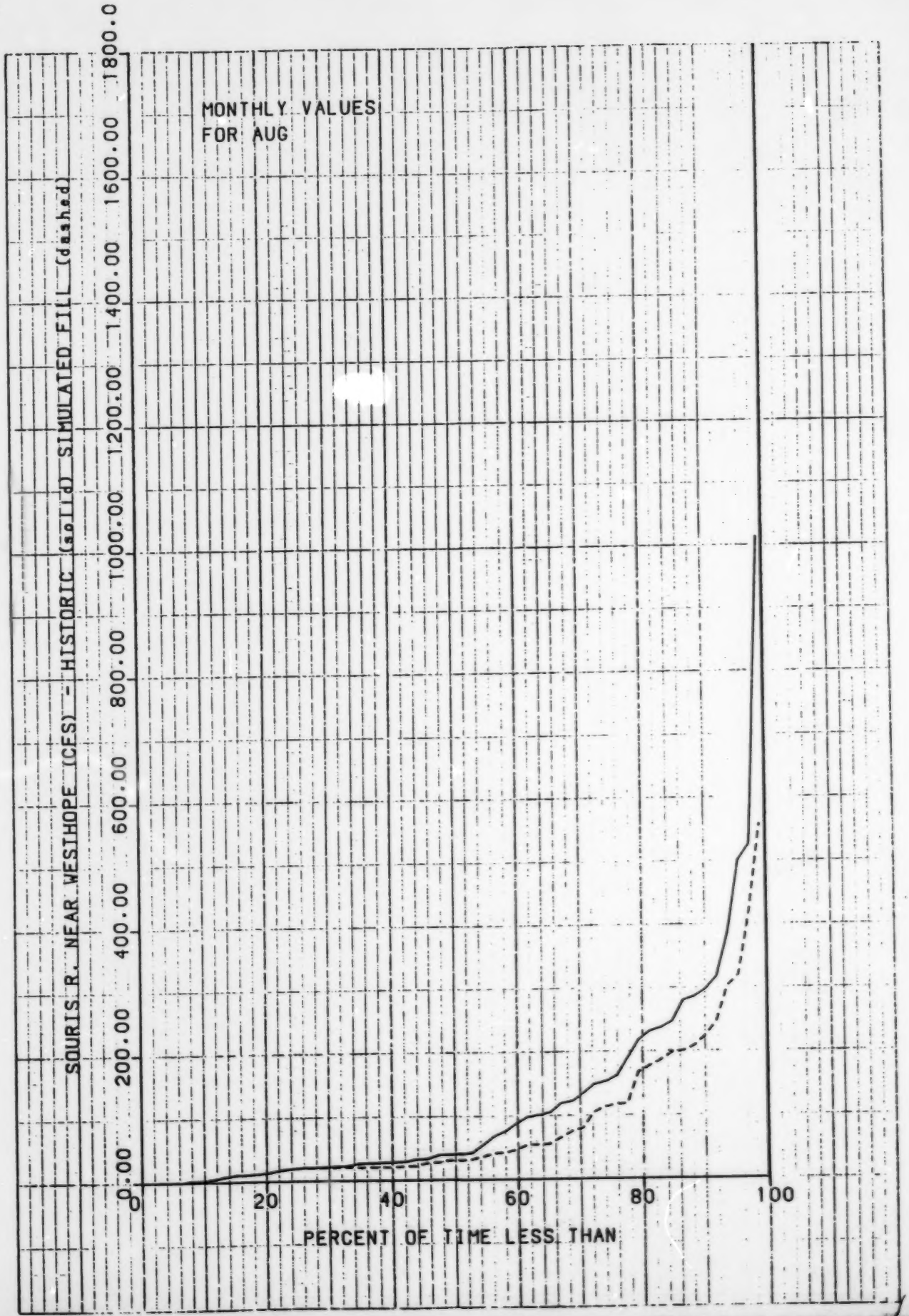
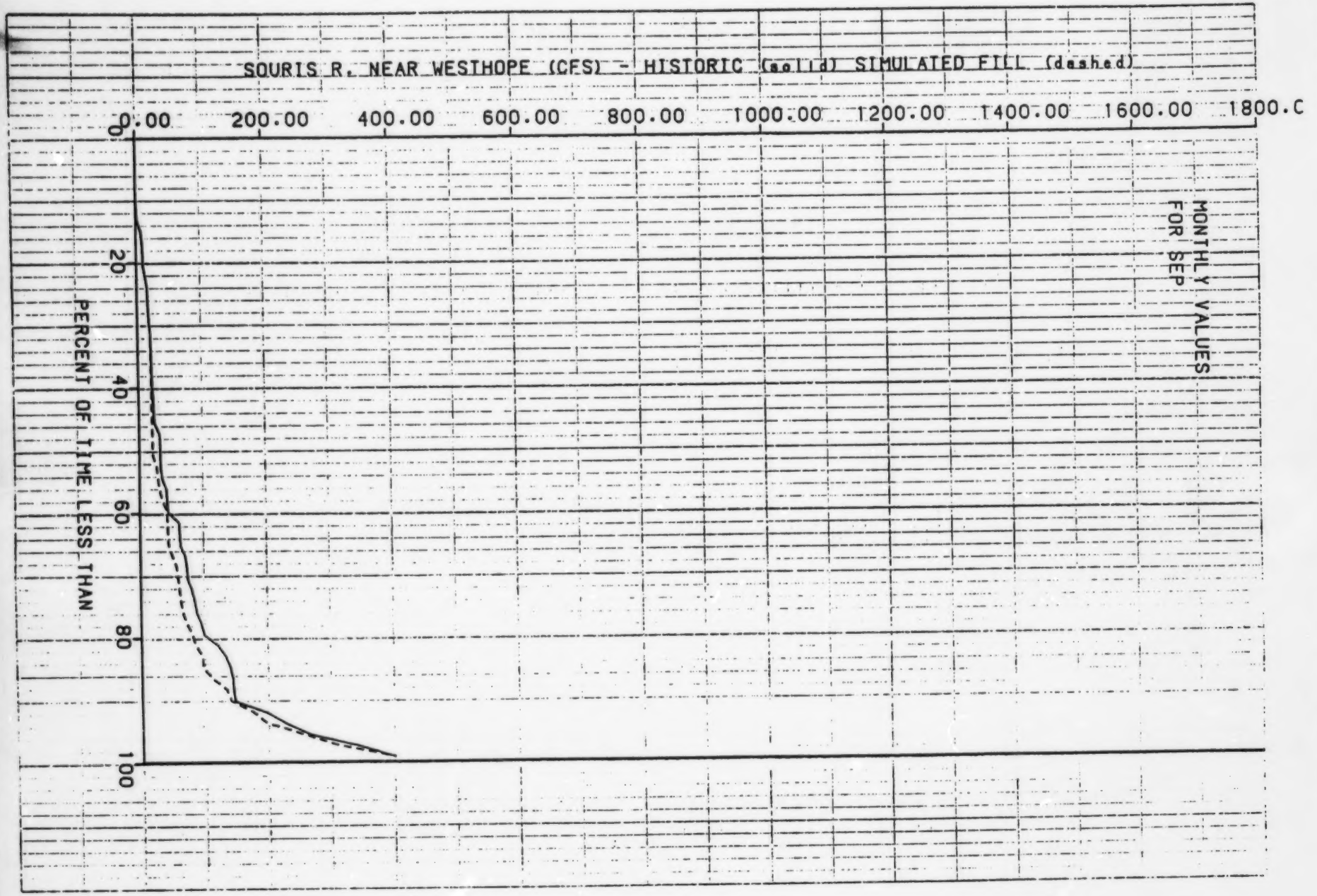
80
100
PERCENT OF TIME LESS THAN
MONTHLY VALUES
FOR JUL


MONTHLY VALUES
FOR AUG
SOURIS R. NEAR WESTHOPE (CFS) - HISTORIC (solid) SIMULATED FILL (dashed)
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00
1800.0
0
20
40
60
80
100
PERCENT OF TIME LESS THAN


SOURIS R. NEAR WESTHOPE (CFS) - HISTORIC (solid) SIMULATED FILL (dashed)
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400.00
600.00
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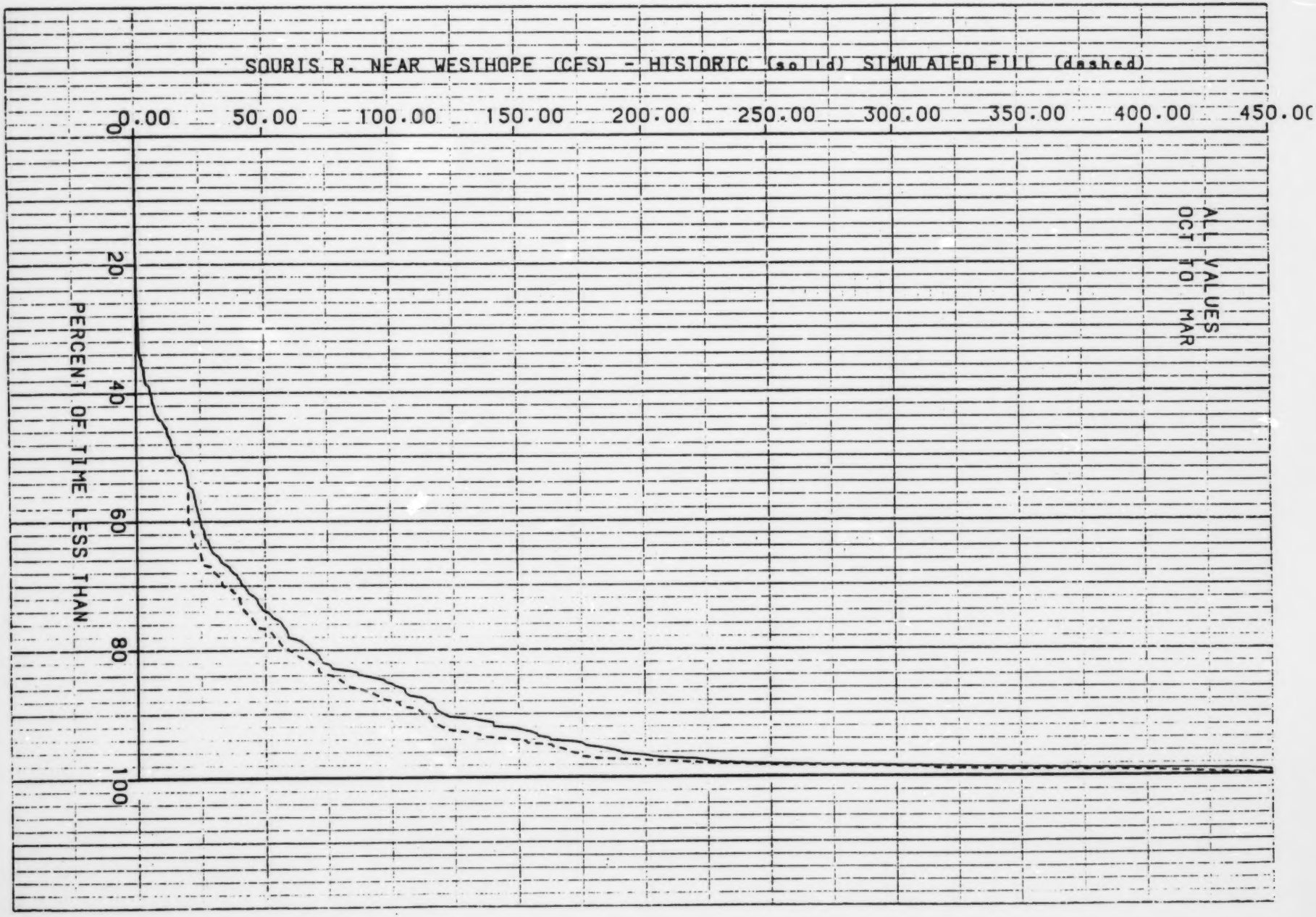
100
PERCENT OF TIME LESS THAN
MONTHLY VALUES
FOR SEP


SOURIS R. NEAR WESTHOPE (CFS) - HISTORIC (solid) SIMULATED FIL (dashed)
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20
40
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80
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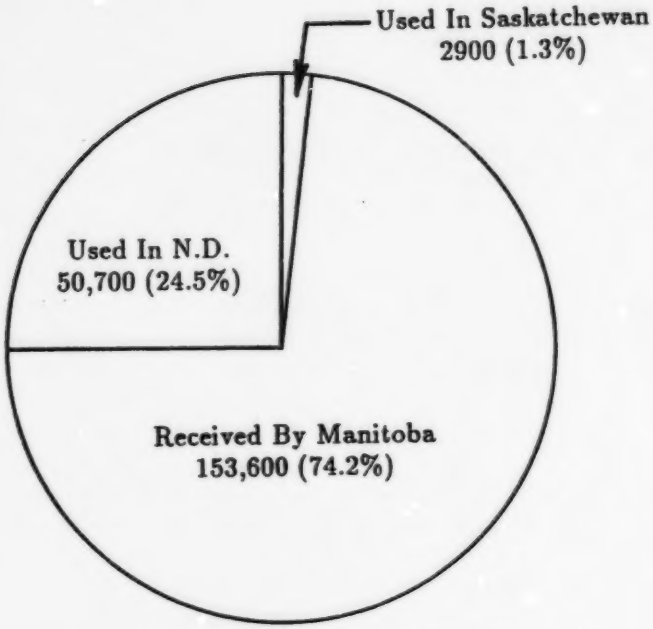
PERCENT OF TIME LESS THAN
ALL VALUES
OCT TO MAR

Average Annual Flows

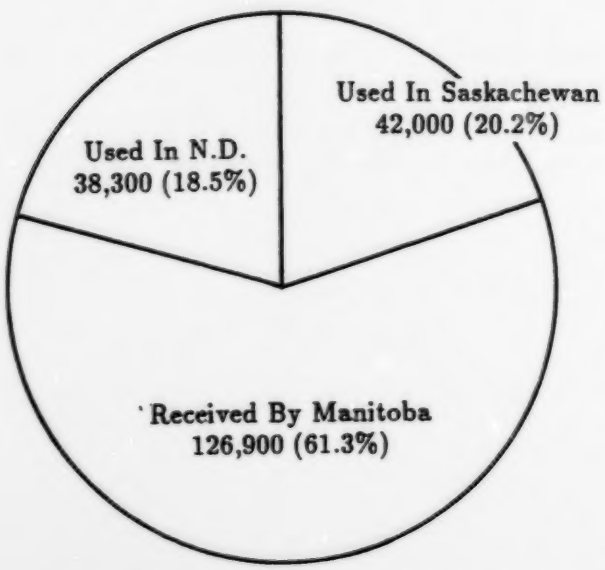
AVERAGE ANNUAL FLOW VOLUMES (acre - feet) at MANITOBA - NORTH DAKOTA BOUNDARY



HISTORIC RECORD

NOTE: Full circles represent total flow received by Manitoba under Natural Conditions

(207,200 acre-feet)



AFTER RAFFERTY / ALAMEDA

Average Annual Flow Volumes (Acre-Feet)
based on 1930-1974 data

	Natural Flow	Historic Flows	Post-Project Flows
Total Flows:			
Sherwood	84,800	81,900	42,800
Westhope	207,200	153,600	126,900
Wawanesa	298,900	241,000	214,300
Flows arising in:			
Saskatchewn	84,800	81,900	42,800
North Dakota	122,400	71,700	84,100
Manitoba	91,700	87,400	87,400
Water Usage:			
Saskatchewan	0	2,900	42,000
North Dakota	0	50,700	38,300
Maintoba	0	4,300	4,300

1. Under natural flows there would be no man-induced water usage.

2. Much of Saskatchewan's increased usage would be in the form of evaporation from the reservoir surfaces.

3. Water usage in North Dakota would be reduced largely by operating the reservoirs at lower levels, thereby reducing evaropation.

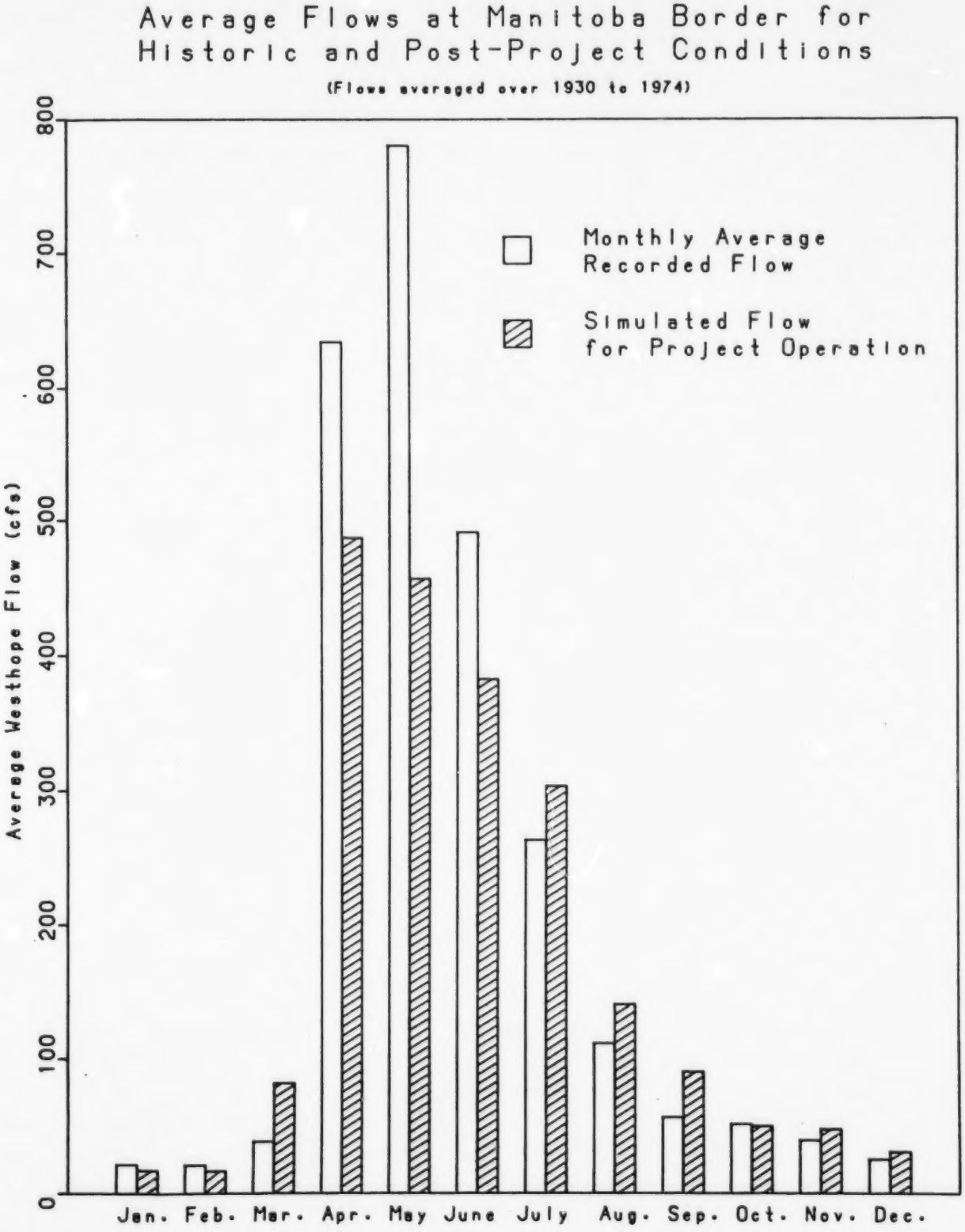

Average Flows at Manitoba Border for
Historic and Post-Project Conditions
(Flows averaged over 1930 to 1974)
Average Westhope Flow (cfs)
0
100
200
300
400
500
600
700
800
Monthly Average
Recorded Flow
Simulated Flow
for Project Operation
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sep.
Oct.
Nov.
Dec.

FIGURE 1

APPENDIX 8

MANITOBA RESPONSE TO THE SOURIS BASIN DEVELOPMENT AUTHORITY

"SOURIS RIVER WATER QUALITY AT THE SASKATCHEWAN/NORTH DAKOTA BORDER"

Manitoba COPY

Environment and Workplace Safety and Health | Environmental Management | Building 2, 139 Tuxedo Avenue, Winnipeg, Manitoba, CANADA R3N 0H6

December 17, 1987

Mr. George Hood
Director of Planning and Operations
Souris Basin Development Authority
814 - 4th Street
ESTEVAN, Saskatchewan
S4A 0V9

Dear Mr. Hood:

As requested at the December 1, 1987 meeting in Winnipeg on the Rafferty/Alameda Project, Manitoba Environment and Workplace Safety and Health has relayed our initial water quality concerns to your stated contact (Mr. Dennis Brown to Mr. Rodger McDonald; December 10, 1987). The following constitutes the substance of our initial concerns related to water quality:

1.) Manitoba Environment staff have reviewed the Summary Output document and Overview Report from the water quality workshop held in Regina, Saskatchewan on November 18-20, 1987. Some basic questions arose during the review related to data calibration and data input.
* background data use
* data use from similar systems
* irrigation return flow quality
* organics.
* diurnal dissolved oxygen fluctuations
* downstream algal biomass
* comparison to similar systems

In discussions with Environment Canada staff and Mr. Rodger McDonald some of these points have been briefly clarified.

2.) It is recommended that a water quality technical committee, comprised of <u>all</u> jurisdictions, should be formally established to guide the water quality review. Manitoba Environment would be prepared to take an active part on the committee.

3.) It is our position that the proponents should formalize the water quality predictions at the Saskatchewan/North Dakota boundary by drafting a technical report. This report should include information to meet the concerns stated in 1.

4.) It is our position that the proponents should examine water quality predictions at the North Dakota/Manitoba border. This report should consider, among other issues the following:

* operation of Rafferty Dam
* operation of Alameda Dam
* operation of Lake Darling
* operation of J. Clark Salyer Refuge
* low flow effects on dissolved oxygen, algal biomass, etc. on the lower Souris River.
* Manitoba surface water quality objectives for the Souris River.

City of Minot

5.) It is recommended that transboundary water quality objectives guidelines and/or alert levels be set for the Souris River at the two international crossings.

I trust the above is sufficient for the present time. Mr. Dennis Brown and Mr. Dwight Williamson will be representing Manitoba Environment and Workplace Safety and Health at the upcoming meeting on water quality on December 21 and 22, 1987 in Regina, Saskatchewan.

Yours truly,

N. B. Brandson
Director
Environmental Management
Services Branch

DJB/lp

X.C: T. Weber
Wm Gummer
D.J. Brown

Manitoba

Environment and Workplace Safety and Health

Environmental Management

Building 2
139 Tuxedo Avenue
Winnipeg, Manitoba, CANADA
R3N 0H6

December 24, 1987

Mr. George Hood
Director of Planning and Operations
Souris Basin Development Authority
ESTEVAN, Saskatchewan
S4A 0V9

Dear Mr. Hood:

The following information is provided in accordance with your request emanating from the December 21 and 22, 1987 meetings in Regina. As stated in my December 17, 1987 letter to you, it is the position of Manitoba Environment and Workplace Safety and Health that the proponents should formalize the water quality predictions at the Saskatchewan/North Dakota boundary by drafting a technical report. It is my understanding that such a report will be prepared and will be distributed to all interested agencies. The production of the report will allow my staff to better evaluate the potential effects on Manitoba from the construction of Rafferty Dam, Alameda Dam and Shand Thermal Generating Station as well as the operating regimes of these structures. As indicated at the meeting, Manitoba Environment staff are prepared to dialogue as necessary, to aid those persons responsible for the preparation of the report. The contact person is Mr. Dennis Brown, Head, Water Standards and Studies (204-945-7033).

As stated at the December 21-22, 1987 meeting by Dennis Brown, the report should contain at least the following:

* an indication of background data use.
* a comparison to similar systems.
* irrigation return flow quality and potential effects.
* effects on water quality at Saskatchewan/North Dakota boundary to filling of reservoirs, low flow conditions, average conditions and high flow conditions.
* the parameters of concern at the present time are dissolved oxygen, phosphorus (dissolved and total), nitrogen (TKN, nitrate, ammonia) and downstream algal biomass.

As previously stated, it is our position that the proponents should prepare a technical report which considers, the effects of the following projects on water quality at the Manitoba/North Dakota boundary:

* operation of Rafferty Dam
* operation of Alameda Dam
* operation of Lake Darling
* operation of J. Clark Salyer Refuge
* City of Minot sewage effluent

etc.

The report should relate to the projects' collective potential effects on transboundary water quality (Manitoba/North Dakota). In particular, the effect of reduced and/or altered flows on the algal biomass of the lower Souris River as well as transboundary dissolved oxygen concentrations, phosphorus (dissolved and total) and nitrogen (TKN, nitrate, ammonia) should be evaluated.

It is my understanding that the transboundary water quality issues will continue to be openly discussed by an ad hoc Water Quality Technical Advisory Committee which will include Manitoba Environment. Manitoba Environment is prepared to take part and contribute as necessary.

It is imperative, from our perspective, that transboundary water quality objectives, guidelines, and/or alert levels be established for the Souris River at the two international crossings. This will go a long way to ensure that the downstream interests of Manitoba related to long term water quality are protected.

Manitoba is prepared to take an active role in the development of these water quality objectives and is hopeful that these can be established by December, 1988. Such water quality objectives should be developed considering pre-Rafferty/Alameda baseline water quality conditions. This exercise will go part way to alleviate some of Manitoba Environment's initial concerns.

Yours truly,

Original Signed by
N. B. BRANDSON

N.B. Brandson,
Director,
Environmental Management
Services Branch

DJB/cn

x.c.: T. Weber
Wm. Gummer
D.J. Brown

APPENDIX 9

ENVIRONMENT CANADA REVIEW OF SOURIS BASIN DEVELOPMENT AUTHORITY

"SOURIS RIVER WATER QUALITY AT THE SASKATCHEWAN/NORTH DAKOTA BOUNDARY"

Environment Canada / Environnement Canada

Environmental Conservation / Conservation de l'environnement

1st Floor, Motherwell Building
1901 Victoria Avenue
Regina, Saskatchewan
S4P 3R4

Your file / Votre référence

Our file / Notre référence
7031-5-1
(0460G)

1988 05 03

Mr. G. Hood
Director of Planning and Operations
Souris Basin Development Authority
814 - 4th Street
Estevan, Saskatchewan
S4A 0Y9

Dear Mr. Hood:

The report "Souris River Water Quality at the Saskatchewan/North Dakota Boundary", February 1988, is a very good accounting of what went into the computer simulations. The document goes a long way to clarifying the water quality assumptions and expected Saskatchewan impacts attributable to the project. The following notes are provided for your information and use. I would be willing to discuss these with you.

1. The results confirm there is a potential for water quality degradation in the Saskatchewan reach of the Souris River, with recovery in the River being a function of the hydrologic regime and distance from the project area. The construction of instream weirs, for irrigation draw-offs, may play a role in alleviating dissolved oxygen and ammonia problems, but they may also create havens for prolific undesirable biological growths.

2. The water quality problems in the Saskatchewan reach of the Souris River, which are readily measurable, include dissolved oxygen, unionized ammonia, instream nutrient enrichment and associated problems, and biological substrate stability. In this latter case, I am now of the opinion that the biological communities in the river may be significantly altered on account of a more regulated flow. This isn't necessarily bad, but there seems to be little consideration of what the biological community response will be to hydrologic changes. The conclusion that "algal biomass will flourish but in similar populations to the presently encountered", page 64, is not substantiated within the report.

3. What is the impact of the weirs on fish migration (spring), spawning and the normal fish movement during other times of the year? Flows in the Souris River are normally low during the period of June to March so restriction to fish movement is likely a natural phenomena. Have the fisheries people dealt with this?

continued page 2....

Canada

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4. It is reasonable to expect the organic nitrogen to increase in the Souris River on account of agricultural influence and increased biomass in the reservoirs/quiescent reaches of the river. The extent to which this increase is offset by removing the Estevan sewage effluent could be assessed through a nutrient budget analysis.

5. The potential for alteration to the major ion characteristics of the River is high, especially on account of evaporation in the reservoirs. Leaching of dissolved salts is less a concern in my view. Although different flow regimes were simulated, I do not recall testing successive dry years when, as is being experienced in Cookson Reservoir, dissolved salts can be expected to increase. Such simulation alternatives is desirable and could possibly illustrate increases in dissolved salt content but still within acceptable levels for downstream water uses.

6. Degradation to stream quality downstream of the International Boundary, and which is directly related to the project, has yet to be explicitly dealt with. What effect will there be on the trophic status of Lake Darling? The lake is so advanced now that any marginal decrease or increase in P loading will likely have little consequence. This is conjecture on my part.

7. "....the data do not reflect full utilization of Saskatchewan's share of the wate. under an equitable apportionment system." I am not sure why this statement, page 5, is being made. I have no fundamental argument with the statement although it must be noted that water quality under a full apportionment scenario may not necessarily be at variance with the existing quality (for some parameters). Also, some quality characteristics may be worse and others better. For example, under lower flows, there will be lower P loadings, whereas dissolved oxygen recovery within the river will not be as effective and instream temperatures will be higher. The assimilative capacity (and dilution) of the river will be reduced under a scenario where Saskatchewan holds back more water than has been done historically, with anthropogenic impacts being more noticeable and measureable...perhaps.

8. The upsurge of metals in the reservoir will take place with inundation. As is noted mercury can be expected to increase in the fish, reaching stabilization many years down the road. I see no substantive evidence to suggest that the time frame is "short term". I think there are many factors which will affect this time frame, from residence time to microbial conditions in the sediment substrates. I suspect mercury will be more a local (fish consumption) than an international issue.

9. I have passed the report to the Water Resources Branch, Inland Waters Directorate, to obtain their views on the time of travel projections used in the models. If, as is implied, time of travel significantly affects the water quality predictions, then a better handle is required on time of travel estimates.

10. The diffuse source quality assumptions are reasonable estimates in my view.

11. I am uncomfortable with the conclusion that "trophic upsurge could elevate normal reservoir nutrient levels by 1.5 to 2 times for the first two to four years". The supporting data, which seems to be from Cookson Reservoir, do not provide sufficient evidence to make this projection. I have no data to help, however, and would hope that post-project monitoring (studies) would obtain this information for future use in other projects.

12. The USEPA recently provided some computer simulation results using their own models. I am happy to see that their conlusions are essentially the same for dissolved oxygen. Their assumptions, which have led to higher predicted unionized ammonia concentrations, should be reconciled with those of your consultant. The organic nitrogen assumptions seem to be one such point of disagreement.

13. Is there any 1988 plan to collect field data specifically for the Souris River which will allow the forecasting of most likely conditions? See page 33, last sentence.

14. There seems to be optimism that a dual (multi) port discharge will be constructed at Alameda. I think this is a good management decision as it will provide one means for dealing with possible deteriorated water quality and meeting our international obligations.

15. On the question of pesticides and trace metals, I feel that the situation will be virtually no different than what we see in other agricultural districts. Pesticides and their prevalence in the Souris River will depend very much on irrigation practices and the pesticides used. Given that the trend is towards nonbioaccumulative pesticides which break down readily in the environment (short latency period) with impacts being more local than regional, I would not expect to see a quantifiable change downstream in the USA from what is observed presently. It must be realized, however, that current monitoring practices in both countries have not focussed on the effects of pesticides on aquatic life. In the larger scheme of things much research still remains to be done in the 'effects' area.

16. Although this report does not evaluate the effects of the Saskatchewan project on Manitoba, I feel that the direct effects of Rafferty/Alameda will be barely discernable, if at all, at the boundary of North Dakota and Manitoba. However, the Saskatchewan Project will be accompanied by USA-designed-hydrologic-works in the U.S. portion of the Souris River which could have quantifiable impacts on Manitoba. I am not sure to what extent the Souris Development Authority can distance itself from this reality.

17. The commitment to measurement and assessment (monitoring) programs to detect trends and to provide a basis for undertaking remedial action is commendable.

continued page 4

In time I expect the U.S. Corps EIS, the Saskatchewan EISs and the review comments from various agencies will have to be considered as one complete package in order to fully comprehend the collective impacts which may accrue within the basin. Apparently, the U.S.A. EIS process will come to conclusion in the fall of 1988. Following this date, another joint jurisdictional workshop may be warranted to review the predictions and to consider future monitoring requirements. I would hope that this could be achieved through a formal process, perhaps through the International Joint Commission or a Bilateral Arrangement. In the immediate future due consideration should be given by all proponents of the proposed hydrologic changes in the upper Souris River Basin to the possible water quality impacts downstream in Manitoba.

Yours sincerely,

Wm. D. Gummer
Chief, Water Quality Branch
Inland Waters Directorate
Western and Northern Region

c.c. D. A. Fast
N. Brandson
R. A. Halliday
H. Hickman

APPENDIX 10

MANITOBA RESPONSE TO U.S. ARMY CORPS OF ENGINEERS

DRAFT ENVIRONMENTAL IMPACT ASSESSMENT

EM11-2

Manitoba

Environment and Workplace Safety and Health

Environmental Management

Building 2
139 Tuxedo Avenue
Winnipeg, Manitoba, CANADA
R3N 0H6

January 18, 1988

Mr. Charles E. Workman
District Engineer
U.S. Army Engineer District, St. Paul
1135 U.S. Post Office and Custom House
St. Paul, Minnesota
55101-1479

Dear Mr. Workman:

Staff have reviewed the report entitled "Souris River Basin Project, General Plan and Draft Environmental Impact Statement, Public Review Copy", November, 1987, prepared by the U.S. Army Corps of Engineers, St.Paul District.

Our concerns remain similar to those expressed during a meeting held in Regina, Saskatchewan on December 21 and 22, 1987, which was convened to discuss outstanding water quality concerns of the Rafferty/Alameda dam project. Mr. Dennis Holme from your office was present at this meeting. It is our position that the proponents the Souris Basin Development Authority and U.S. Army Corps of Engineers should prepare the necessary technical reports that explicitly examine the water quality impacts that may occur at the North Dakota/Manitoba boundary as a result of the collective changes following the construction of facilities and altered system management . This report should consider the combined effect of the following projects:

* operation of Lake Darling
* operation of Rafferty Dam
* Operation of Alameda Dam
* operation of J. Clark Salyer Wildlife Refuge
* effect of reduced flow on existing discharges, such as the City of Minot sewage effluent

Parameters or conditions of particular concern are the effect of altered flow (low, mean and high) regimes on algal biomass in the lower Souris, transboundary dissolved oxygen concentrations, dissolved and total phosphorus and nitrogen species including ammonia.

Should you have any questions with regard to the above or can provide additional information, please do not hesitate to contact either myself at 945-7007 or Mr. Dennis Brown at 945-7033.

Yours truly,

N. B. Brandson, Director
Environmental Management
Services Branch

DJB/lp
BCC: D. Brown
D. Williamson

APPENDIX 11

PROPOSED MANITOBA WATER QUALITY STUDY

POTENTIAL WATER QUALITY EFFECTS IN MANITOBA FROM THE RAFFERTY/ALAMEDA PROJECT

BACKGROUND

The Souris River originates in south-eastern Saskatchewan and flows through northern North Dakota into Manitoba. The river travels approximately 200 kilometers within manitoba, from the Manitoba/North Dakota boundary to the Assiniboine River.

In 1986, the Province of Saskatchewan announced their intention to proceed with the construction of the Rafferty and Alameda dams on the Souris River system. The project is intended to be a multiple-objective project. It is being cost-shared with U.S. agencies due to flood protection benefits for the City of Minot. At the present time, numerous agencies in both Canada and the U.S. are reviewing potential water quality impacts at the Saskatchewan/North Dakota border arising from the projects.

However, a long-term water quality concern may be present in the lower Souris River within Manitoba. In the past, low flow conditions in the spring were partially responsible for the filamentous algae blooms Cladophora sp. downstream of the Town of Souris (Beck, 1981). The bloom persisted throughout the summer period and impaired aesthetic value of the stream, interfered with recreational activities and reduced dissolved oxygen concentrations to critical concentrations for fisheries protection. The study concluded that in May 1981, the nuisance growth of Cladophora sp. was caused by a combination of reduced precipitation, abnormally low flows and significantly greater than normal amounts of sunlight coupled with the normally optimal nutrient concentrations in the Souris River. Once the bloom was established, it was maintained through the summer period.

The filling period and various operating scenarios of the Rafferty and Alameda dams may create similar conditions in future years to those which occurred in 1980. In addition, the normal operations of these new dams, coupled with the operations of other control structures in the Souris River watershed, may give rise to frequent nuisance filamentous algae blooms within Manitoba. These frequent nuisance bloom conditions may significantly impair the existing water uses within Manitoba.

It is proposed that a study be carried out on the lower Souris River within Manitoba, to determine the effects of flow rate in controlling the growth of Cladophora sp.

An Investigation of the Influence of Flow Rate, Nutrient Availability, Incident Light and Temperature upon the Production of Cladophora in the Souris River, Manitoba.

It is proposed that a sampling site be established on the Souris River, east of the town of Souris. Such a site would ideally have ready access to the river and would preferably be close to a source of electricity. The site should also be one where natural substrata for the production of Cladophora are present in the River.

It is proposed to construct a series of flow through troughs at the edge of the river such that river water can be pumped through them at a range of flow rates. The range to be used will encompass as best as is possible the lower portion of the range of flow rates that have been recorded at Wawanesa during the last twenty years ($0.45\text{-}194.0\ m^3 s^{-1}$). Flow rate in the troughs would be controlled by adjustable gates. At each established flow rate, a light gradient would be established by the use of acrylic screens of known transparency. Each trough would be lined with removable artificial substrata for the colonization by algae. Physical and chemical data would be gathered at regular intervals and would include flow rate, light intensity, water temperature, and concentrations of major ingredients.

At regular time intervals, artificial substrata would be removed from each trough and each light situation, and the following biological parameters of attached algae determined: biomass (estimated as phaeophyton corrected chlorophyll a per unit of substratum surface area); photosynthetic characteristics (as estimated from measured rates of $^{14}CO_2$ uptake); and algal community structure (as the biovolume of each algal species per unit of substratum surface area).

Factor analysis of the resulting data matrix should permit estimation of the role of flow rate, light, temperature and nutrient availability upon the production of attached algae (including Cladophora).

Since this model would be based on a semi-artificial controlled experiment, it is also proposed to monitor the production of Cladophora and other attached algae on the Souris River itself, along with the above physical and chemical parameters. The purpose of this would essentially be to compare the occurrence of algae in the river with occurrence predicted by the model.

It is proposed that this would be a two-year study and comprise the M.Sc. research of one graduate student. Data should be available for two ice-free seasons although part of the first year would certainly be occupied in establishing the experimental system described above. In the following budget, no allowance has been made for nutrient analysis or monitoring of flow rate. This is based upon the assumption that analyses would be conducted through Government of Manitoba analytical facilities and that flow monitoring equipment would be available through the Department of Environment and Workplace Safety and Health. No allowance has been made for negotiation of a power supply and permission to establish a sampling site on private property.

BUDGET

	Year 1 1988-89	Year 2 1989-90
Salaries		
Summer stipend for Graduate Student*	5,000.00	5,000.00
Summer stipend for Assistant	5,500.00	5,500.00
Accommodation		
At Souris and University of Manitoba Field Station for 2 persons	4,300.00	4,300.00
Field Subsistence for 2 persons	3,600.00	3,600.00
Travel		
30 round trips from Winnipeg to Souris	3,400.00	3,400.00
Materials and Equipment		
1 Monarch JKS - 1 Jet Pump	400.00	-
1 Monarch JKS - S4 Jet Pump	600.00	-
Pump pipes and fittings	200.00	-
Trough construction	2,000.00	-
Artificial Substrata	500.00	500.00
Chlorophyll Analysis	500.00	500.00
Photosynthesis Determinations	1,000.00	1,000.00
Miscellaneous	1,000.00	1,000.00
TOTAL	$28,000.00	$24,800.00

*Note: There is a possibility that a graduate student would have scholarship support. This is not yet known and is certainly more likely for Year 2 than for Year 1.

APPENDIX 12

MANITOBA WATER QUALITY OBJECTIVES

SOURIS RIVER PRINCIPAL WATERSHED DIVISION

WATER QUALITY OBJECTIVES FOR MANITOBA AS APPLIED TO SURFACE WATER CLASSIFICATION IN THE SOURIS RIVER PRINCIPAL WATER SHED DIVISION

WATER QUALITY OBJECTIVES FOR MANITOBA AS APPLIED TO SURFACE WATER CLASSIFICATION IN THE SOURIS RIVER PRINCIPAL WATERSHED DIVISION

The following data provide detailed descriptions of the water quality objectives associated with the stream classifications recommended for adoption in Table 9 of Appendix "B" to this report. The source of these descriptions is Part II, Appendix "D", Clean Environment Commission *Report on a Proposal Concerning Surface Water Quality Objectives and Stream Classification for the Province of Manitoba*, May 1978 (revised May 1979).

Class 1C - Domestic Consumption

The quality of this class of the waters shall be such that with treatment consisting of coagulation, sedimentation, filtration, softening, storage and chlorination, or other equivalent treatment processes, the treated water will meet in all respects the acceptable limits of the Canadian Drinking Water Standards and Objectives 1968 for drinking water, and any revisions, amendments or supplements thereto. This objective will ordinarily be restricted to waters not considered to afford adequate protection against contamination from surface or other sources of pollution.

Substance or Characteristic	Acceptable Limit or Range
Arsenic (As)	0.01 mg/l
Barium (Ba)	1 mg/l
Boron (B)	5.0 mg/l
Cadmium (Cd)	0.01 mg/l
Chloride (Cl)	250 mg/l
Chromium (Cr^{6+})	0.05 mg/l
Color	15
Copper (Cu)	1 mg/l
Cyanide (CN)	0.01 mg/l
Faecal Coliform Organisms	At least 90% of the samples in any consecutive 30 day period should have a faecal coliform density of less than 100 MPN per 100 ml.
Fluoride (F)	1.2 mg/l
Iron (Fe)	0.3 mg/l
Lead (Pb)	0.05 mg/l
Manganese (Mn)	0.05 mg/l
Mercury (Hg)	0.002 mg/l
Methylene Blue Active Substance (MBAS)	0.5 mg/l

Substance or Characteristic	Acceptable Limit or Range
Nitrate and Nitrite (N)	10 mg/l
pH	5.0 - 9.0
Phenol	0.001 mg/l
Radioactive Material	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.
Selenium (Se)	0.01 mg/l
Silver (Ag)	0.05 mg/l
Sulphate (SO_4)	250 mg/l
Threshold Odour Number	4
Total Coliform Organisms	At least 90% of the samples in any consecutive 30 day period should have a total coliform density of less than 1000 MPN per 100 ml.
Total Dissolved Solids	1000 mg/l
Turbidity	25
Zinc (Zn)	5 mg/l

Class 2B - Fisheries and Recreation

The quality of this class of the waters shall be such as to permit the propagation and maintenance of cool or warm water sport or commercial fishes and be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.

Substance or Characteristic	Acceptable Limit or Range
Ammonia (N) unionized	0.02 mg/l
Cadmium (Cd)	0.01 mg/l for waters with hardness greater than 100 mg/l ($CaCO_3$)
	0.004 mg/l for waters with hardness lower than 100 mg/l ($CaCO_3$)
Chloride (Cl)	200 mg/l
Chlorine (Cl_2)	0.01 mg/l
Chromium (Cr^{6+})	0.1 mg/l
Colour	30
Copper (Cu)	0.02 mg/l or not greater than 1/10 the 96-hour LC50 value
Cyanide (CN)	0.005 mg/l

Substance or Characteristic	Acceptable Limit or Range
Dissolved Oxygen	47% or more saturation at the ambient temperature
Faecal Coliform Organisms	The median (50 Percentile) based on not less than 5 samples per month should be not greater than 200 MPN per 100 ml.
Fluoride (F)	1.5 mg/l
Lead (Pb)	0.03 mg/l
Mercury (Hg)	0.0002 mg/l
Nickel (Ni)	0.025 mg/l
pH	6.5 - 9.0
Polychlorinated Biphenyls (PCB)	0.000002 mg/l
Radioactive Material	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.
Selenium (Se)	0.01 of the 96-hour LC50 value
Silver (Ag)	0.01 of the 96-hour LC50 value
Sulphide (H_2S)	0.002 mg/l
Temperature	No change greater than 1.0° Celsius beyond natural minimum and maximum temperatures.
Thallium (Tl)	0.05 mg/l
Total Coliform Organisms	The median (50 percentile) based on not less than 5 samples per month should be not greater than 500 MPN per 100 ml.
Turbidicy	25
Uranium (U)	0.01 mg/l or .01 of the 96-hour LC50 value
Zinc (Zn)	.01 of the 96-hour LC50 value

Class 3B - Industrial Consumption

The quality of this class of the waters shall be such as to permit their use for general industrial purposes, except for food processing, with only a moderate degree of treatment.

Substance or Characteristic	Acceptable Limit or Range
Arsenic (As)	0.05 mg/l
Barium (Ba)	1 mg/l
Cadmium (Cd)	0.01 mg/l
Chromium (Cr^{6+})	0.05 mg/l
Chloride (Cl)	100 mg/l
Cyanide (CN)	0.2 mg/l
Faecal Coliform Organisms	The median (50 percentile) based on not less than 5 samples per month should be not greater than 200 MPN per 100 ml.
Fluoride (F)	1.5 mg/l
Hardness ($CaCO_3$)	250 mg/l
Lead (Pb)	0.05 mg/l
pH	6.0 - 9.0
Radioactive Material	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.
Selenium (Se)	0.01 mg/l
Silver (Ag)	0.05 mg/l
Total Coliform Organisms	At least 90% of the samples in any consecutive 30 day period should have a total coliform density of less than 5000 MPN per 100 ml.

Class 4B - Agriculture and Wildlife

The quality of this class of the waters shall be such as to permit their use for irrigation without significant damage or adverse effects upon crops, vegetation or soil, and represents irrigation water of acceptable quality.

Substance or Characteristic	Acceptable Limit or Range
Aluminum (Al)	1.0 mg/l
Arsenic (As)	0.1 mg/l
Beryllium (Be)	0.1 mg/l
Boron (B)	0.3 mg/l
Cadmium (Cd)	0.01 mg/l
Chloride (Cl)	350 mg/l

Substance or Characteristic	Acceptable Limit or Range
Chlorine (Cl_2)	0.05 mg/l
Chromium, Total (Cr)	0.05 mg/l
Cobalt (Co)	0.05 mg/l
Copper (Cu)	0.20 mg/l
Detergents and Saponates	40 mg/l
Faecal Coliform Organisms	The median (50 percentile) based on not less than 5 samples per month should be not greater than 1000 MPN per 100 ml.
Fluoride (F)	1.0 mg/l
Iron (Fe)	5.0 mg/l
Lead (Pb)	5.0 mg/l
Lithium (Li)	2.5 mg/l
Manganese (Mn)	0.2 mg/l
Mercury (Hg)	0.005 mg/l
Molybdenum (Mo)	0.01 mg/l
Nickel (Ni)	0.20 mg/l
Nitrate and Nitrite (N)	30 mg/l
pH	5.0 - 9.0
Radioactive Materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.
Selenium (Se)	0.02 mg/l
Sodium (Na)	60% of total cations as milli-equivalents per litre.
Specific Conductance	2000 µmho/cm
Sulphate (SO_4)	400 mg/l
Sulphide (H_2S)	5 mg/l
Total Dissolved Solids (Filterable Residue)	1500 mg/l
Vanadium (V)	0.10 mg/l
Zinc (Zn)	2.0 mg/l

Class 4C - Agriculture and Wildlife

The quality of this class of the waters shall be such as to permit their use by livestock and wildlife without inhibitory or injurious effects. The limits or concentrations of substances or characteristics given below shall not be exceeded in the waters.

Substance or Characteristic	Acceptable Limit or Range
Aluminum (Al)	5.0 mg/l
Arsenic (As)	0.05 mg/l
Boron (B)	5.0 mg/l
Cadmium (Cd)	0.05 mg/l
Chromium, Total (Cr)	1.0 mg/l
Cobalt (Co)	1.0 mg/l
Copper (Cu)	0.5 mg/l
Faecal Coliform Organisms	The median (50 percentile) based on not less than 5 samples per month should be not greater than 200 MPN per 100 ml.
Fluoride (F)	2.0 mg/l
Lead (Pb)	0.1 mg/l
Mercury (Hg)	0.01 mg/l
Nitrate and Nitrite (N)	100 mg/l
Nitrite (N)	10 mg/l
Pesticides	Not to exceed the limits listed in Table "2"
pH	5.5 - 9.0
Radioactive Materials	Not to exceed the lowest concentrations permitted to be discharged to an uncontrolled environment as prescribed by the appropriate authority having control over their use.
Selenium (Se)	0.05 mg/l
Sulphate (SO_4)	500 mg/l
Total Dissolved Solids (Total Salinity)	3000 mg/l
Toxic Algae	Avoid use of water bearing heavy growth of blue-green algae.
Unspecified Toxic Substances	None at levels harmful either directly of indirectly
Vanadium (V)	0.1 mg/l
Zinc (Zn)	25 mg/l

Class 5 - Navigation and Waste Disposal

The quality of this class of the waters shall be such as to be suitable for aesthic enjoyment of scenery and to avoid any interference with navigation or damaging effects on property. The following limits or concentrations shall not be exceeded in the waters

Substance or Characteristic	Acceptable Limit or Range
Faecal Coliform Organisms	The median (50 percentile) based on not less than 5 samples per month should be not greater than 1000 MPN per 100 ml.
pH	4.5 - 10.0
Sulphide (H_2S)	0.02 mg/l

Additional selective limits may be imposed for any specific waters as needed.

Class 6 - Other Uses

The uses to be protected in this class may be under other jurisdictions and in other areas to which the waters of the province are tributary, and may include any or all of the uses listed in the foregoing categories, plus any other possible beneficial uses. The Department, therefore, reserves the right to impose any standards necessary for the protection of this class, consistent with legal limitations.

TABLE "1"

Water Quality Objectives for Pesticides in
Public Water Supply, Livestock Watering and Water Contact Recreation
[Concentration in Whole (Unfiltered) Water]

Pesticide	Type	Not to Exceed Limit - µg/l
Aldrin	D	1.0
Chlordane	D	3.0
2,4-D	A	100.
Diazinon	B	I.I.*
Dichlorvos	B	I.I.
Dieldrin	D	1.0
Dimethoate	B	I.I.
DDT	D	42.
Endrin	D	0.2
Ethion	B	I.I.
Heptachlor	D	0.1
Heptachlor Epoxide	D	0.1
Lindane	D	4.0
Methoxychlor	D	100.
Methyl Parathion	B	I.I.
Monocrotophos	B	I.I.
Parathion	B	I.I.
Toxaphene	D	5.0
2, 4, 5-TP	A	10.0
All organophosphates and carbamates, total	B,C	100.

Type - A - Herbicides
B - Organophosphates
C - Carbamates
D - Organochlorines

* Note: Insufficient Information (I.I.)
Due to a general lack of data, scientifically defensible objectives cannot be set at the time.

TABLE "2"

Water Quality Objectives for Pesticides,
Freshwater Aquatic Life and Wildlife
[Concentration in Whole (Unfiltered) Water]

PESTICIDE (by common name)	CODE (Note 1)	TYPE (Note 2)	NOT TO EXCEED LIMIT (micrograms per liter)
Aldrin plus Dieldrin	-	D	0.003 (Note 3)
Allethrin	-	-	0.002
Amitrole	3	A	300.
Azinphos-methyl	1,2	B	0.001
Carbaryl	1,2	C	0.02
Chlordane	-	D	0.04
Chlorpyrifos	-	B	0.001
Coumaphos	-	B	0.001
Crotoxyphos	-	B	0.10
2,4-D (BEE)	2,3	A	4.0
Dalapon	2,3	A	110.
DDT	-	D	0.002
DDVP	-	B	0.001
Demeton	-	B	1.0
Diazinon	2	B	0.009
Dicamba	2,3	A	200.
Dichlobenil	-	A	37.
Dichlone	-	A	0.2
Dieldrin			(See Aldrin)
Dioxathion	-	B	0.09
Diquat	3	A	0.5
Disulfoton	2	B	0.05
Diuron	3	A	1.6
Endosulfan	1,2	D	0.003
Endrin	-	D	0.002
EPN	-	B	0.06
Ethion	-	B	0.02
Fenac	-	A	45.
Fenitrothion	-	B	10.0
Heptachlor	-	D	0.005
Heptachlor Epoxide	-	D	0.005
Lindane	1	D	0.02
Malathion	1	B	0.008
Methoxychlor	-	D	0.005
Mevinphos	-	B	0.002
Mexacarbate	-	C	0.10
Mirex	-	D	0.001
Naled	-	B	0.004

TABLE "2" (cont'd)

PESTICIDE (by common name)	CODE (Note 1)	TYPE (Note 2)	NOT TO EXCEED LIMIT (micrograms per liter)
Oxydemeton-methyl	-	B	0.4
Parathion -	-	B	0.0004
Phosphamidon	-	B	0.03
Picloram	2,3	A	9.0
Pyrethrum	-	-	0.01
Rotenone	-	-	10.
Silvex (phenoxyproprionic)	3	A	30.
Silvex (BEE)	-	A	2.5
Silvex (PGBE)	-	A	2.0
Simazine	3	A	10.
TDE	-	D	0.006
Temophos	-	B	100.
TEPP	-	B	0.4
Toxaphene	2	D	0.01
Trichlorfon	1,2	B	0.002

Note 1

Codes - 1 - Insecticides used in vegetable and field production in Southern Manitoba.

2 - Pesticides expected to be used in North Dakota irrigation.

3 - Herbicides in use in Manitoba.

Note 2

Types - A - Herbicides, Fungicides & Defoliants

B - Organophosphate insecticide

C - Carbamate insecticide

D - Organochlorine insecticide

Note 3

Pesticide limits to protect freshwater aquatic life are generally based on multiplying the acute toxicity values for the most sensitive important fish species by an application factor of 0.01. With respect to a number of pesticides in use in Manitoba and adjoining States or Provinces, due to a general lack of data, scientifically defensible objectives cannot be set at this time. The limits for these, to protect aquatic life, should be based on 0.01 of the 96-hour LC50 value determined using the receiving water in question and the most sensitive important fish species in the area as test organism.